New Scientist

WEEKLY 20 November 2021

65TH
ANNIVERSARY
SPECIAL

do we exist?
do we grieve?
are we irrational?
is there a cosmic speed limit?
does evolution happen?
are we conscious?
does time only move forwards?
is there something rather than nothing?
is the universe intelligible?
haven't we heard from aliens?
is quantum theory so strange?
are we good and evil?
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This week's issue

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Podcast

COP26 special

The *New Scientist* reporting team in Glasgow, UK, reflect on their experiences of the crucial COP26 climate summit and the pledges nations have made. They also discuss high-income countries' attempts to make up for breaking their 2015 promise to pay $100 billion to help lower-income nations tackle climate change. We also hear from special guests including climate scientist Emily Shuckburgh and former UN diplomat Christiana Figueres.

newscientist.com/nspod

Podcast

DOMINIKA ZARZYCKA/NURPHOTO/SHUTTERSTOCK

Keep 1.5°C alive Climate protesters gathered in Glasgow, UK, last week

Newsletter

AB PHOTOGRAPHIE/SHUTTERSTOCK

Here, boy! Why did we domesticate animals like dogs so recently?

Video

Vanessa Nakate

Watch a clip of climate activist Vanessa Nakate speaking at COP26 in Glasgow, UK. "The atmosphere doesn't care about commitments, it only cares about what we put into it or stop putting into it," she says. Don't forget to subscribe to our channel for more discoveries and explainers, including extra coverage from the climate summit.

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Newsletter

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Get Michael Marshall's newsletter delivered free to your inbox each month. The latest instalment looks at how humans domesticated animals and plants. One of the biggest questions is why many examples of this seem to have happened so late in humanity's 300,000-year history.

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> “Humans have domesticated dozens of species of animals and plants”

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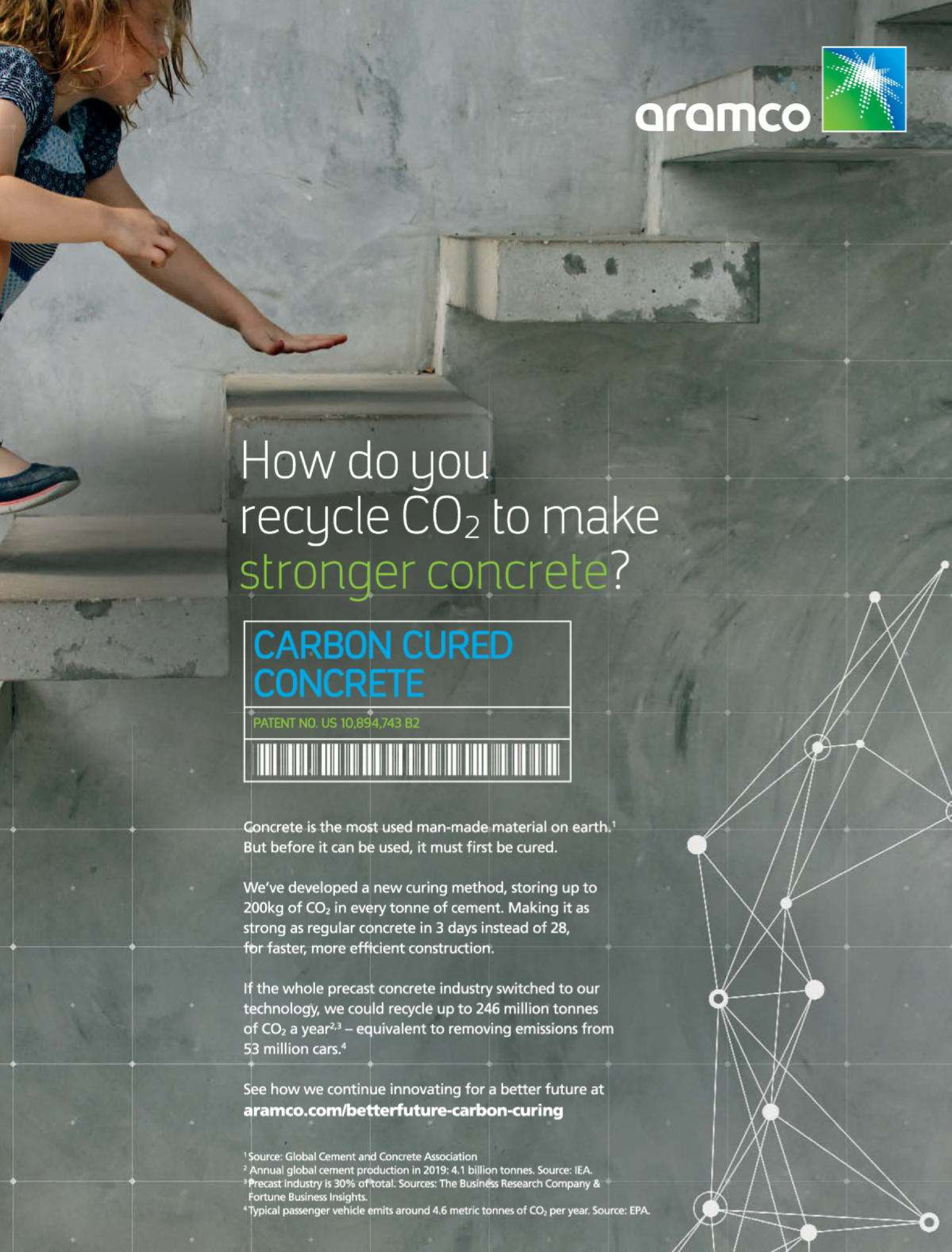

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[1] Source: Global Cement and Concrete Association
[2] Annual global cement production in 2019: 4.1 billion tonnes. Source: IEA.
[3] Precast industry is 30% of total. Sources: The Business Research Company & Fortune Business Insights.
[4] Typical passenger vehicle emits around 4.6 metric tonnes of CO_2 per year. Source: EPA.

The climate age

As *New Scientist* turns 65, one issue will and must dominate our next decades

"THE world has entered a phase of spectacular technological advances." So *The New Scientist* wrote on 22 November 1956 when introducing its mission. Nuclear bombs had fallen on Hiroshima and Nagasaki a little over a decade before, the digital computer was in its infancy and the space race was just beginning.

The desire to "publish news of scientific progress in language as free as possible from technicalities" was the spur of this magazine's foundation, but right from the outset we were clear about the need to look further. "For a branch of research which, today, appears as a purely abstract quest for knowledge, may turn out tomorrow to have a direct and vital application to the happiness of us all," we wrote. "Besides, science is exciting; science can be entertaining."

These sentiments remain as fresh and true today, and as much a part of our mission statement, as they were 65 years ago. It is in that spirit that we have brought together 13 great "why?" questions about the cosmos and ourselves in this issue, questions that excite and entertain, and take us to the very edge of our understanding (see page 36).

> "Climate change and issues about our environmental impact aren't going to go away"

One subject was conspicuously absent from our first issue, perhaps understandably so. It wasn't until two years later, in 1958, that Charles Keeling began the measurements at the Mauna Loa Observatory in Hawaii that first alerted the world to rising levels of carbon dioxide in the atmosphere. The growing awareness of the catastrophic effects on people and the planet of many of those spectacular technological advances – and in recent decades our consistent failure to do anything about it – has been a feature of this magazine's existence.

Whether the COP26 climate conference that ended last week in Glasgow, UK, represents a turning point remains to be seen (see pages 8, 9 and 10). Climate change and wider issues surrounding our environmental impact aren't going to go away. Fulfilling our mission statement from that first issue, we will continue to report on them in the coming decades, as well as on all aspects of science and its impact on society, "conscientiously – and readably". ▮

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JANUARY
2022

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Turi King
Professor of Genetics and Public Engagement, University of Leicester

WHY CALORIES DON'T COUNT

Giles Yeo
Principal Research Associate and MRC Investigator, MRC Metabolic Diseases Unit, University of Cambridge

THE EXPECTATION EFFECT: HOW YOUR MINDSET SHAPES YOUR HEALTH, HAPPINESS, AND LONGEVITY

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Science Writer and author

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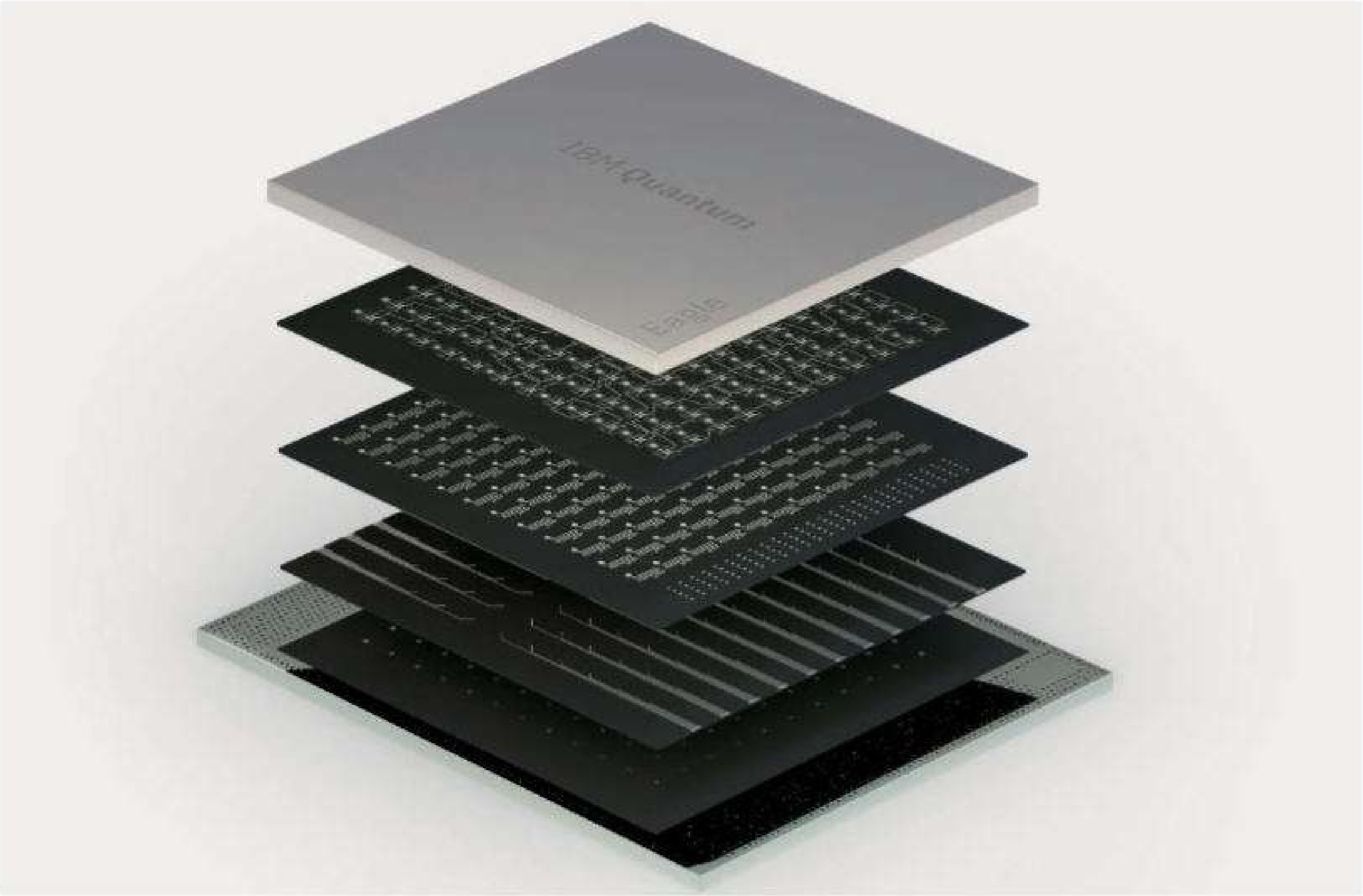
Europe's tree deaths Drier soils could be to blame for dying plants p14

Lunar oceans Subsurface oceans may be lurking on Uranus's moons p15

Covid-19 T-cells Pre-existing immunity hints at universal jab p19

Psychedelic therapy Largest trial of psilocybin for depression yet p20



IBM

IBM's Eagle processor has 127 quantum bits

Quantum computing

A new quantum leader?

IBM has built a quantum computer that has twice as many qubits as its nearest rivals, reports **Matthew Sparkes**

IBM claimed on Monday that it has created the world's largest superconducting quantum computer, surpassing the size of state-of-the-art machines from Google and from researchers in China. Previous devices have demonstrated up to 60 superconducting qubits, or quantum bits, but IBM's new Eagle processor more than doubles that by stringing together 127.

Several approaches are being pursued to create a practical quantum computer, including using superconductors and entangled photons. It remains unclear which one will become the equivalent of the transistors that powered the classical computing revolution.

In 2019, Google announced that its Sycamore processor, which uses the same superconducting architecture that IBM is working with, had achieved quantum supremacy – the name given to the point at which quantum computers can solve a problem that a classical computer would find impossible. That processor had 54 qubits, but has since been surpassed by a 56 and then 60-qubit demonstration with the Zuchongzhi superconducting processor at the University of Science and Technology of China (USTC) in Hefei.

> **"One additional qubit effectively doubles a quantum processor's potential power"**

IBM's 127-qubit Eagle processor now takes the top spot as the largest, and therefore theoretically most powerful, superconducting quantum computer to be demonstrated. Each additional qubit represents a significant step forwards in ability. Classical computers rise in power in a linear fashion as they grow, but one additional qubit effectively doubles a quantum processor's potential power.

Canadian company D-Wave Systems has sold machines for some years that consist of thousands of qubits, but they are widely considered to be very specific machines tailored towards a certain algorithm called quantum annealing rather than fully programmable quantum computers. In recent years, much progress in quantum computing has focused on superconducting qubits, which are one of the main technologies that Google, USTC and IBM are backing.

Bob Sutor at IBM says that breaking the 100-qubit barrier is more a psychological than physical achievement, but that it shows the technology can grow. "With Eagle, we're demonstrating that we can scale, that we can start to generate enough qubits to get on a path to have enough computation capacity to do the interesting problems. It's a stepping stone to bigger machines," he says.

However, it is difficult to compare the power of the IBM chip with previous processors. Both Google and USTC used a common test to assess such chips, which was to simulate a quantum circuit and sample random numbers from its output. IBM claims to have created a more programmable and adaptable processor, but has yet to publish an academic paper setting out its performance or abilities.

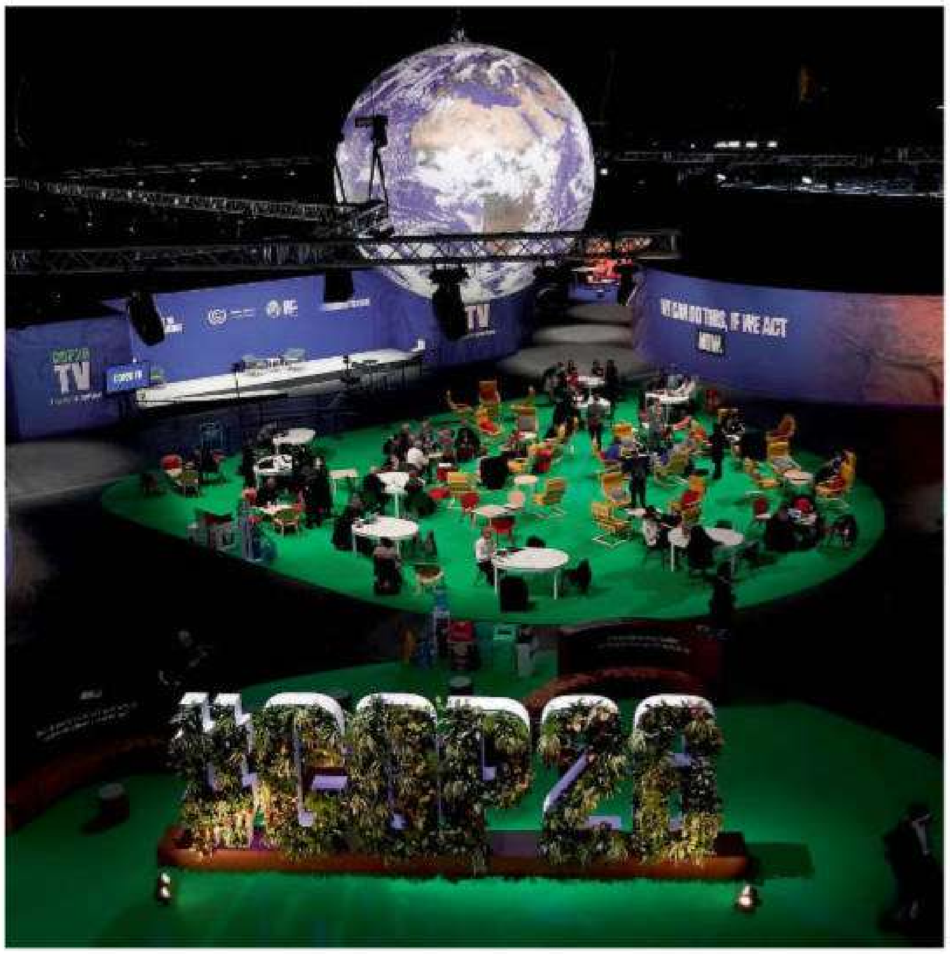
It is tempting to assess performance entirely on the qubit count, says Peter Leek at the University of Oxford, but there are other metrics that need to be looked at, none of which has yet been released for Eagle. "It's good that they're making something with more qubits, but ultimately it only becomes useful when the processor performs really well," he says.

IBM has said that it hopes to demonstrate a 400-qubit processor next year and to break the 1000-qubit barrier the following year with a chip called Condor. ▮

Two weeks in Glasgow

How the drama unfolded

A fortnight of talks, side deals, sleepless nights and protests at the climate summit ended with a shock last-minute intervention. This report and analysis opposite by **Adam Vaughan**



ALBERTO PEZZALI/AP/SHUTTERSTOCK

For two weeks, Glasgow was the centre of the world's attention

"WHEN will leaders lead?" asked Mia Mottley at the start of the COP26 climate summit on 1 November. More than 100 world leaders had gathered in Glasgow, UK, but it was the speech by the prime minister of Barbados that stood out. With Earth on course for 2.7°C of global warming ahead of the landmark conference, Mottley warned that 2°C would be a "death sentence" for countries on the front line of climate change.

Impassioned speeches soon gave way to side deals on everything from deforestation to methane. They were non-binding, often missing key countries and replete with caveats. But they will make a difference, if followed with action. One analysis found they could lower 2030 emissions by 2 billion tonnes of carbon dioxide, about 5 per cent of 2021's levels.

> "In a last, unexpected twist, India intervened to weaken pledges over ending coal use"

These pledges saw the first week of the conference end with momentum, despite campaigner Greta Thunberg deriding the summit as a "PR exercise". An estimated 100,000 climate protesters marched through Glasgow's streets on 6 November.

Climate adaptation was meant to be the official theme at the start of the second week, but the surprise arrival of former US president Barack Obama, followed by US politicians Alexandria Ocasio-Cortez and Nancy Pelosi, meant that the US held much of the focus instead. While acknowledging progress in Glasgow, Obama said: "We are nowhere near where we need to be."

The first draft of a final "cover decision" – the agreement from the summit – arrived before sunrise on 10 November. It included plans to phase out coal and subsidies for fossil fuels, and "urged" nations to submit more ambitious plans in 2022, in a push to meet the 2015 Paris Agreement's goals of keeping warming "well below" 2°C and pursuing 1.5°C.

Summit president Alok Sharma found its final moments emotional

REUTERS/PHIL NOBLE

COP26 was in the "hard yards" of negotiations, as UK prime minister Boris Johnson said later that day, with differences over finance and more. Even the usually upbeat Johnson struggled to explain how to unblock the impasse.

Yet only an hour later, China's special climate envoy Xie Zhenhua lifted the mood with a surprise announcement of a US-China agreement to raise the climate ambition of both countries in the 2020s. The declaration was light on substance, but it marked a vital shift after US president Joe Biden accused Chinese president Xi Jinping of a "big mistake" in not attending COP26.

A new draft decision failed to materialise on 11 November, and it was reported that one bloc of countries had suggested deleting the entire section on cutting emissions. In the ensuing lull, people watched the cricket at the conference's Pakistan pavilion.

The Mexican delegation offered COP26 president Alok Sharma a bottle of tequila if the talks finished on time, at 6pm on 12 November. A new alliance of nations working to end future oil and gas extraction was launched.

COP26's crunch came in the last 48 hours. It began with weakened language: the "phase out" would now apply to fossil fuels that are "inefficient" and to coal use that was "unabated", giving room for its use with carbon capture and storage. Countries were now "requested" instead of "urged" to revise their plans next year, sparking debate over the minutiae of which is the stronger verb.

The talks spilled over into 13 November. At a meeting on the final proposed text, nations listed grievances. "It's not perfect," said Tina Stege of the Marshall Islands. But none rejected it outright.

In a last, unexpected twist, at the final meeting to approve the decision, India's environment minister Bhupender Yadav intervened. Coal should see a "phase-down" not "phase-out", he said. China backed the change, but Switzerland, speaking on behalf of six countries, was applauded for expressing "profound disappointment" at the watered-down wording. The European Union said "coal has no future". Stege said the change "hurts deeply". But, in a bid not to lose all that had been agreed, no one blocked the change.

Sharma said he was "deeply sorry" at the turn of events and stopped mid-sentence, visibly emotional. "Hearing no objections, it is so decided," he said, and his gavel came down. The Glasgow Climate Pact was sealed. ▮

What difference will it make? Despite last-minute changes, the agreement made at COP26 still amounts to an important ratcheting up of climate ambition

IS THE 1.5°C goal still alive? The answer is a good way to boil down the mind-boggling complexity of whether the COP26 summit, which finished in dramatic fashion last Saturday, puts humanity on the path that climate science calls for.

Six years ago in Paris, 195 countries committed to this temperature goal as their line in the sand for limiting future global warming, in addition to holding it "well below" 2°C. Yet the emissions-cutting plans put forward in 2015 left the world facing a cataclysmic 3.5°C of warming by 2100.

That is why nations in Paris also agreed a "ratchet mechanism" to upgrade the plans by the end of 2020. Many missed the deadline, so COP26 in Glasgow, UK, became the de facto cut-off point.

This first crank of the ratchet yielded a mixed bag of plans. Some big emitters, including the European Union, Japan, the UK and the US, significantly deepened how much they say they will cut emissions by the end of the decade. China and India upped their ambition, but their emissions will still rise this decade. Many other sizeable polluters, including Australia, Brazil and Indonesia, didn't issue improved plans.

The net result leaves us in a better position, but one that is still nowhere near good enough: an Earth about 2.4°C hotter than pre-industrial times, according to an authoritative analysis by Climate Action Tracker, a non-profit scientific body in Germany, that assumes countries deliver on their 2030 emissions targets.

That is why the inconspicuous paragraph 29 of the newly forged Glasgow Climate Pact, gavelled in late on Saturday, is so crucial. It requests countries submit stronger plans next year for how much they plan to curb emissions by 2030. And those plans must also be aligned with the 1.5°C goal, a more precise and tougher requirement than the pre-COP26 commitment for a "progression" in successive plans.

The question now is: will countries cough up new plans? The UK, which is already committed to a steep 68 per cent emissions cut by 2030, is unlikely to do more. Australia, Brazil and the Philippines have national elections next year, so citizens could elect leaders with a mandate to go further.

Corinne Le Quéré at the University of East Anglia, UK, says the package of pledges in Glasgow keeps the 1.5°C goal alive, but only just. "The language is really important. Every word has been ramped up to a level above what it was before," she says. The target is alive but "hanging by a thread", says Chris Stark at the Climate Change Committee, an independent body that advises the UK government. COP26 president Alok Sharma has said 1.5°C remains alive, but even he concedes its "pulse is weak".

3.5°C

2015 prediction of this century's global warming

2.4°C

Predicted warming after COP26, if promises are kept

1.5°C

The warming goal of the 2015 Paris Agreement

Negotiators in Glasgow also set a precedent by referring directly to coal and to fossil fuel subsidies in the final agreement. This is the first time this has happened in 26 years of UN climate summits. India's last-minute weakening of the language used, from a "phase-out" of coal to a "phase-down", doesn't really matter, says Emma Pinchbeck at trade group Energy UK. It still sends a "really, really powerful market signal", especially to investors, she says. "This is the first time the F-word [fossil fuels] is in a COP decision. It's progress," says Mohamed Adow at think tank Power Shift Africa.

There were many other successes. A pledge to double the money given to help lower-income countries adapt to climate change, such as by building flood defences or planting new crops, to $40 billion by 2025. A decision to work out a global adaptation goal and finance for poorer countries post-2025. Agreement on the "Paris rulebook", a group of rules on everything from transparency to carbon markets that have remained unresolved for six years.

But new rules, a promise to come back next year (to COP27 in Sharm el-Sheikh, Egypt) and woolly language on coal won't satisfy many people rightly anxious about the urgency of climate action. Still, the outcome exceeded the expectations of many veteran observers who spoke to *New Scientist*, including Le Quéré. "There is a mismatch between what perhaps the broader public and the young people think you can achieve in a COP," she says. "You don't achieve everything in a COP."

Critically, COP26 has maintained momentum on climate action and even explicitly spelled out the challenge: "recognizing" that restricting warming to 1.5°C means a global 45 per cent emissions cut by 2030, on 2010 levels. Governments must now translate their pledges into policies and action, an area where even climate leaders like the UK have been found wanting.

Ultimately, UN climate summits alone can only do so much. The battle to keep 1.5°C alive will be won at ballot boxes, on the streets, in courts and in boardrooms. Campaigner Greta Thunberg, who was disappointed by COP26's outcome, tweeted: "Instead of looking for hope – start creating it." ▮

The Marshall Islands's Tina Stege said a change on coal phase-out "hurts deeply"

ALASTAIR GRANT/AP/SHUTTERSTOCK

Negotiations and activism

An emotionally gruelling fortnight for those pushing for change

Jason Arunn Murugesu

CLIMATE talks are arenas of high emotion because, fundamentally, they are about life, death, money, family and people's homes. I saw this emotion in the bleary eyes of the sleep-deprived negotiators at COP26 and heard it in the chants of protesters outside the summit's venue each morning.

Whether they were activists, negotiators or ministers, most of the people I met in Glasgow were steadfast, hard-working and resolutely uncynical. "It's two weeks away from your family, from your friends, eating very bad food and not sleeping," says Kristin Qui, a negotiator for Trinidad and Tobago. The day before, 11 November, she had started work at 8am and finished negotiations at 10pm. "That was an early finish," she says.

> "There's a lot of rhetoric about the science, but some just want to erase any references to it"

Qui was negotiating at the summit on behalf of the Alliance of Small Island States, a coalition of 39 countries, largely from the Caribbean and South Pacific, including Jamaica, Tuvalu, and Antigua and Barbuda. On 8 November, Tuvalu released a recorded message from foreign minister Simon Kofe, delivered knee-deep in the sea at Funafuti, to remind the summit of the impacts of climate change.

For those attending COP26 in person, "negotiations are not only physically exhausting but emotionally exhausting too", says Qui. "But you have to compartmentalise, because if you engage with that exhaustion your body is going to be like: I can't do this any more."

Climate negotiations comprise public meetings and private talks. In public meetings, countries say which parts of the proposed climate deal they do and don't like. "It's where the theatrics happen," says Qui. "But the real discussions happen in informal meetings where there are no facilitators."

"There's a lot of rhetoric from leaders about the importance of [the target to limit global warming to] 1.5 degrees and the importance of science," says Frances Fuller, a negotiator for Antigua and Barbuda. "But then when you get down to some of the technical discussions... there are other parties in the room that just want to erase any references to any foundation of real science."

KEEP 1.5°C
ALIVE
Every climate promise must be kept.
#WEWONTFORGET

KIARA WORTH/UNFCCC

A protester taking part in a COP26 walkout on 12 November

It takes effort to stay calm. "Here I have a job to do and if I were to go into hysterics right now nobody would listen to me," says Qui. This is harder to do at home, she says: "When you see that not enough is being done – you can't compartmentalise."

Arafat Jamal, who works for the United Nations High Commissioner for Refugees, tells me that not enough money is given to lower-income nations to protect them against the worst effects of climate change that are happening right now – about 780,000 Sudanese people have been affected by flooding caused by heavy rain this year alone, for example.

Floods aren't new to Sudan, but they are becoming more frequent and intense, causing a loss of homes, food and livelihoods. "There are 16 million cows in the country," says Jamal. "But they are not equipped to deal with mud. They just stand there and stay stuck."

MINISTRY OF JUSTICE, COMMS. & FOREIGN AFFAIRS/GOV. OF TUVALU

Tuvalu's foreign minister, Simon Kofe, recorded a message from the sea

Last year, higher-income countries gave about $20 billion to lower-income nations to help them adapt to the effects of climate change. In Glasgow, they promised to double this annual figure by 2025, but many poorer countries at COP26 said this simply isn't good enough.

Many people were frustrated with the summit's inability to bring about more radical action. But COP26 wasn't the only show in town. For the second week of November, Glasgow was also home to an alternative meeting: the People's Summit, a gathering of activists and campaigners who shared their experiences of pushing for change.

One evening, Clara Ramos, a lawyer from Brazil who is part of the Parents for Future environmental movement, gave a talk on the legal action she is taking against São Paulo's state government over air pollution. "I have two sons," she said during her presentation. "Will their survival be harder than mine?"

Ramos says her legal case will take 10 to 20 years, but that she is confident of eventual victory.

I found her determination, along with that of Qui, Fuller and Jamal, both resolute and contagious. COP26 was at times disheartening and nearly always overwhelming. But those disappointed with the summit's outcome should take hope from the huge amount of work that took place – and is still happening – behind the scenes. ▮

See page 56 for Feedback at COP26

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Space

Enigmatic Planet Nine may have been seen by a space telescope in 1980s

Jonathan O'Callaghan

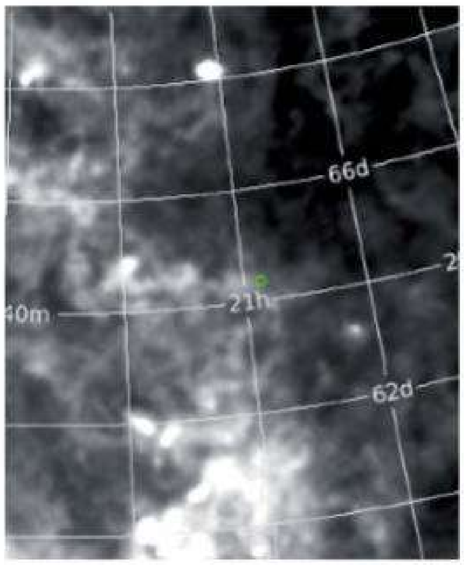
EVIDENCE has been found for a massive planet in the outer solar system, which may be the elusive Planet Nine long sought by astronomers.

Planet Nine is a hypothesised world orbiting far beyond Neptune, in our solar system's outer reaches. The gravitational clustering of some objects in this region suggests the presence of such a world, a super-Earth at least five times as massive as our planet. However, no concrete evidence for it has yet been found.

Michael Rowan-Robinson at Imperial College London examined data from a now-defunct space telescope called the Infrared Astronomical Satellite (IRAS) to look for Planet Nine.

Launched in 1983 and operating for nine months, the telescope surveyed the sky in infrared, discovering objects such as asteroids and comets.

Going back through the telescope's data, Rowan-Robinson looked for evidence of a previously overlooked object orbiting at the proposed distance of Planet Nine, and one candidate stood out.



SCHLEGEL, FINKBEINER AND DAVIS (1998)

Map centred on the Planet Nine candidate (red and green dot)

IRAS detected evidence for an object three to five times the mass of Earth, orbiting about 225 times further from the sun than Earth does, roughly in Planet Nine's expected location (arxiv.org/abs/2111.03831). "It's very tantalising," says Rowan-Robinson.

The limitations of the telescope, however, mean there is quite a bit of uncertainty about whether it is really a planet or not. In particular, the candidate is close to our galactic plane – that is, the thick disc of our galaxy that is full of dust and stars, and some of these might appear deceptively planet-like in a small data set.

3-5

times the mass of Earth – the estimated size of the possible Planet Nine candidate

"But in the data, it does behave quite like a moving object," says Rowan-Robinson, which would suggest it was a planet rather than a distant star.

Mike Brown at the California Institute of Technology, one of the scientists who proposed the existence of Planet Nine in 2016, says that while the finding was interesting, he couldn't be sure the candidate wasn't a false positive.

"This paper was great and I'm really glad he did this analysis," says Brown. But the uncertainties in the data resulting from the proximity to the galactic plane meant it was "hard to pull out signals from all this dust".

Even if the candidate did turn out to be a planet, it doesn't quite fit the expected parameters of Planet Nine. "It's a little too small, it's a little too close and it's quite a bit too inclined to the plane of the solar system," says Brown. "It can't cause those gravitational perturbations that we're seeing. It's not doing what we think is happening."

Nonetheless, Samantha Lawler at the University of Regina in Canada says it is worth having a look at the expected location of this candidate planet, to see if it is really there. "It's a specific prediction for a spot on the sky where there could be something very interesting," she says. "Someone should go observe that spot for sure."

Rowan-Robinson says it is unlikely this candidate world and Planet Nine could both exist. "If this object is real and it is not [Planet Nine], then it is a really remarkable coincidence," he says. ▮

Evolution

Birds in the Amazon are now smaller due to climate change

TROPICAL birds deep in Brazil's Amazon rainforest are shrinking and developing longer wings as they adapt to climate change – but why is something of a mystery.

Researchers studied data for 77 tropical bird species over the past 40 years and found that all of them had lost body mass. Some species have been losing nearly 2 per cent of their weight per decade.

Birds and mammals of the same species are generally larger at higher latitudes. The leading explanation is that their smaller surface-area-to-volume ratio allows them to better conserve heat. The inverse would help smaller species in hot climates to cool and could explain why birds are getting smaller as the climate warms, says Vitek Jirinec at the Integral Ecology Research Center in California, who led the analysis.

In line with this, the mean temperature of the birds' habitat today is 1°C warmer in the wet season and 1.65°C warmer in the dry season compared with 1966. Weather patterns are also more extreme, with 13 per cent more rain falling in the wet season and 15 per cent less in the dry season, and the birds lost mass more sharply after extremely dry or wet seasons.

BLICKWINKEL/ALAMY

A golden-crowned spadebill (*Platyrinchus coronatus*)

This could suggest that body mass loss is partly a short-term response to changes in their environment rather than entirely down to evolution. For instance, a lack of rainfall could cause a decline in the number of insects that the birds feed on, say the researchers.

But none of this can explain the team's other main finding. Wingspan has become significantly larger in one-third of the bird species over the past 40 years (*Science Advances*, doi.org/gnfxjr).

"Mass is a generally good index of body condition in birds," says Jirinec. "If they are simply not getting enough to eat, you would expect them to lose weight. But why would they have more energy to grow their wings?" ▮

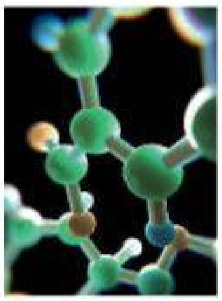
Luke Taylor

Machine learning

AI tool could be used to make tests to spot new drugs fast

Carissa Wong

AN ARTIFICIAL intelligence tool can quickly suggest possible candidates for the chemical structures of psychoactive "designer drugs" from a simple analysis. The tool could fast-track the development of lab tests that screen for drugs with similar effects to cocaine and heroin, but which aren't detectable by current tests.



The structure of a chemical dictates what effects it might have in the body

SCIENCE PICTURE CO/SPL

"Our method could cut down the time required to identify a new designer drug from weeks or months to just hours," says Michael Skinnider at the University of British Columbia in Canada.

Skinnider and his colleagues created a machine learning tool called DarkNPS by training it with the chemical structures of about 1700 known designer drugs. The training set included tandem mass spectrometry results for each drug, which provided information on the mass of the molecule and the elements it contained. This allowed the AI to identify patterns between tandem mass spectrometry data and chemical structures.

Given tandem mass spectrometry data for a previously unseen drug, DarkNPS could then guess the molecular structure with an accuracy of 51 per cent. This increased to 86 per cent if the AI gave its top 10 guesses, meaning it could be most useful for narrowing the search (*Nature Machine Intelligence*, doi.org/g52q).

"This could... make it possible to identify new designer drugs much sooner after they've hit the market," says Skinnider.

Geology

New mineral from the deep

A diamond from Earth's lower mantle contains crystals of a mineral we have never seen before, now named davemaoite, finds **Alice Klein**

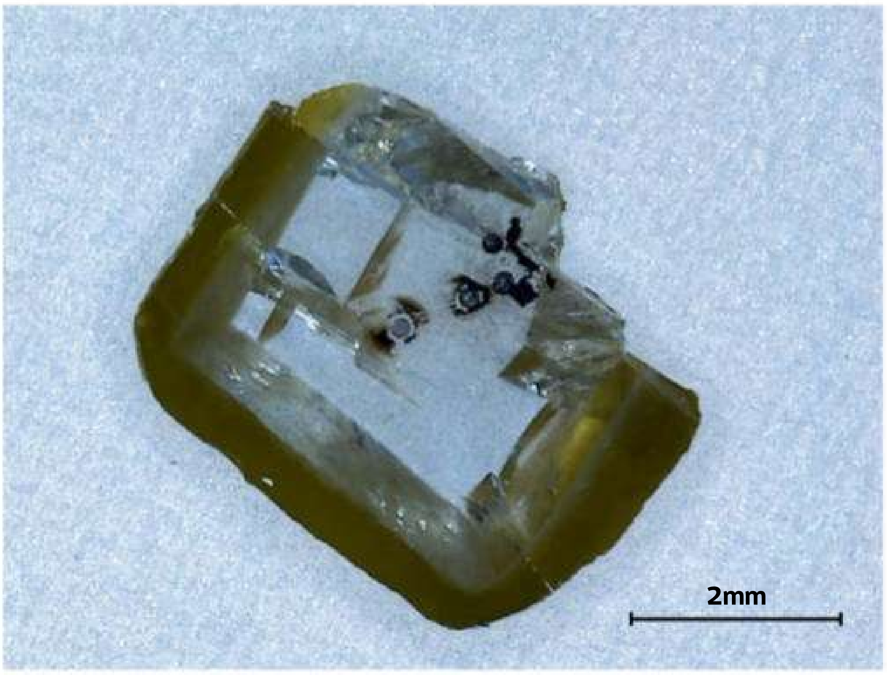
AN ANCIENT diamond found in Botswana contains a never-before-seen mineral that came from deep inside Earth. The mineral – named davemaoite – provides a unique window into deep-Earth chemistry.

Originally dug up in a mine in Orapa, Botswana, the diamond is about 4 millimetres wide and weighs 81 milligrams. A dealer sold it in 1987 to a scientist at the California Institute of Technology who was studying diamonds, but neither the dealer nor the scientist had any idea how special it was.

The diamond, which is now at the Natural History Museum of Los Angeles County in California, was more recently analysed by Oliver Tschauner at the University of Nevada, Las Vegas.

Most diamonds form 120 to 250 kilometres underground, but some are born in Earth's lower mantle, which begins 660 kilometres below the surface. Tschauner and his colleagues realised that the Botswanan diamond was from the lower mantle. After examining it using X-rays, they discovered tiny crystals of another mineral trapped inside.

The tiny diamond that contained the new mineral davemaoite



AARON CELESTIAN/NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY

They used a laser to cut into the diamond to extract these crystals and see what they were made of. The crystals turned out to be a form of calcium silicate that was theorised to exist in the lower mantle but had never actually been observed before. The molecules within it take on a particular cubic arrangement known as a perovskite structure.

The atomic composition of this particular perovskite – which primarily contains calcium, silicon and oxygen – shows it could only have formed under the extreme conditions experienced in the lower mantle, where the pressure is more than 200,000 times that found at Earth's surface.

Tschauner and his colleagues named the new calcium silicate mineral davemaoite in honour of deep-Earth scientist Ho-Kwang "Dave" Mao at the Carnegie Institution for Science in Washington DC (*Science*, doi.org/g5x4).

Normally, davemaoite's crystal structure would break apart if it was brought up to Earth's surface because of the massive drop in pressure. But because it was trapped inside a rigid diamond, it was preserved on its long journey up to the Orapa mine, which probably took between 100 million to 1.5 billion years.

"When we broke open the diamond, the davemaoite stayed intact for about a second, then we saw it expand and bulge under the microscope and basically turn into glass," says Tschauner.

> "When we broke open the diamond, the davemaoite stayed intact for only about a second"

Davemaoite is thought to make up about 5 per cent of Earth's lower mantle, and is important because it is theorised that the mineral can also host radioactive elements like uranium, thorium and potassium-40 that heat Earth as they decay.

"Without these radioactive elements, the Earth would have cooled by now," says David Phillips at the University of Melbourne in Australia.

Tschauner and other researchers are continuing their hunt for super-deep diamonds in the hope of finding more hidden minerals. This is an arduous process, since there are no simple ways of distinguishing between diamonds with shallow or deep origins, and no way of knowing where the deep variety will be found. "The issue is, we don't know quite where to look," says Tschauner.

Ecology

Dry soils mean Europe's trees are dying at a faster rate

Michael Le Page

A EUROPE-wide study has found that the drying out of soils across the continent as the planet heats up is leading to the deaths of more and more trees.

"European forests are suffering," says Jan-Peter George at the University of Tartu in Estonia. "It needs to be made clear to everyone in Europe, regardless of whether you are in the north or the south, that this will become a huge problem."

There is already growing evidence that severer droughts due to climate change are killing off more trees in Europe. But most previous studies have focused on particular areas or been based on satellite surveys, where it is hard to know whether a tree has died or been felled.

George and his colleagues have instead analysed about 3 million on-the-ground observations made as part of an initiative called ICP Forests, which was set up in the 1980s.

Using this data set meant the team could exclude tree deaths that were down to felling. The analysis also excluded ash trees, which are being wiped out by the double whammy of a fungal disease and an invasive beetle.

The researchers found that annual mortality rates are rising for all tree species. Norway spruce has been hardest hit, with mortality rates 60 per cent higher on average between 2010 and 2020 than between 1995 and 2009. Rates are up 40 per cent for Scots pine, 36 per cent for European beech and 3.5 per cent for oak (bioRxiv, doi.org/g5xd).

What's more, for all species and regions, annual mortality rates have been positive since 2012. This means that more trees have been dying than usual, compared with the long-term average. "This could mean that European forests reached a critical point in 2012," says George.

MATTHIAS SCHRADER/AP/SHUTTERSTOCK

A forest on Brocken mountain near Schierke, Germany

The researchers also looked at soil moisture, as estimated by a model fed with rainfall and run-off data. They found that abnormally low soil moisture was the main driver of tree deaths over the following year.

In northern regions such as Scandinavia, many people still think local forests won't be affected by warming-driven droughts, says George, but all forests across Europe are already being affected, including northern boreal ones.

"It is a very unsettling study, but also not surprising," says Hannah Mowat at Fern, an organisation in Brussels, Belgium, that campaigns to protect forests. "It's not just the Amazon forest that is drying up, our own forests are parched, and it is causing them to die back too."

The researchers cannot be sure why trees often die a year or so after droughts, but there are many possible reasons, says George. Severe water stress starves trees of resources and can also damage the water-conducting tissues, making them vulnerable to other stresses such as pests and diseases.

For instance, drought-hit conifers produce much less resin than they would normally, and resin is what protects them from bark beetles. "Bark beetles love to attack drought-stressed trees," says George.

"This is evidence that to climate-proof our forests, we need to make them more diverse"

Rising tree deaths will have many consequences. For starters, forests will soak up less carbon as older trees are replaced by younger ones.

"There is no question that old-growth forests are able to sequester more carbon than young forests," says George. However, he thinks it is unlikely that Europe's forests will become a carbon source in the long term.

Europe is also already suffering from more frequent and severe wildfires, and more dying trees will increase the danger even further. "As more and more dry and dead material accumulates, forests will be much more vulnerable to wildfires," says George. "This is the dynamics we usually know from the US and Australia."

The timber industry could also be affected. One of the reasons why Norway spruce is the species hardest hit is that it has been planted in areas outside its natural range for timber production, typically in monoculture plantations. Forest owners need to start growing a mix of species to make plantations more resilient, says George.

There could be economic consequences, too. Timber prices in Europe are already high because of demand from the US and China, says George. Rising tree losses could push prices even higher and have knock-on effects on the building industry and beyond.

"This is also yet again evidence that to climate-proof our forests, to make them more resilient, we need to make them more diverse," says Mowat. "This study is a rude awakening, but it could mean that the forests of tomorrow are actually more biodiverse, if we heed the scientists making this wake-up call."

A lack of water due to global warming is far from the only threat to Europe's trees. Exotic pests and diseases have decimated elms and now ashes, and threaten other trees including oaks. Wood harvesting has also increased by 50 per cent since 2016. ▮

Space

Biggest moons of Uranus may have subsurface oceans

Leah Crane

URANUS's largest moons, Titania and Oberon, may be hiding buried oceans. Surface temperatures averaging around -200°C mean the water-rich worlds are covered in ice, but radioactive elements deep inside these moons may keep some of their interior water melted.

The smaller moons that orbit closer to Uranus get most of their internal warmth from tidal heating, in which the gravity of the planet stretches each moon's core, creating friction and heat. But tidal heating wouldn't be enough to melt the ice beneath the larger, more distant moons' frozen surfaces.

Carver Bierson at Arizona State University and Francis Nimmo at the University of California, Santa Cruz, calculated whether two of those distant moons, Titania and Oberon, could have oceans anyway, kept liquid by heat from the decay of radioactive elements in their cores.

This also depends on how porous the ice shells of the moons are – a less porous shell is better at conducting heat, so it can escape away into space – and whether the moons' water contains ammonia, which lowers the melting temperature of a water-rich mixture.

The researchers found that if Titania had an ice shell porosity of more than 12 per cent, or more than 10 per cent ammonia in its sea by weight, heat from the radioactive decay in its core should allow for the presence of a liquid ocean more than a kilometre thick. The numbers are similar for Oberon, as the two moons are roughly the same size (*Icarus*, doi.org/g5x3).

Ammonia has been found on several other icy bodies in the solar system, and Earth's moon has an average porosity of about 12 per cent extending down several kilometres, so these numbers are far from outrageous, says Nimmo. "I'd bet they do have oceans," he says. ▮

Analysis Coronavirus

Should we be worried by wild animals with covid-19?

There may be a "silent epidemic" of SARS-CoV-2 in deer in the US, and other wildlife might carry it too, finds **Michael Le Page**

RECENT studies suggest that SARS-CoV-2, the virus that causes covid-19, is rife among the 30 million white-tailed deer in North America. This means there is a risk of deer infecting other species, and also of new variants emerging in other animals and jumping back to people. So what does this mean for the pandemic and how concerned should we be?

It has long been clear that people with SARS-CoV-2 are occasionally infecting pets, farm and zoo animals. Such outbreaks have also led to cases in humans – for instance, in November 2020, Denmark culled millions of mink after the virus began spreading in farmed mink and these animals then infected a few farm workers. Until now, however, it was thought that outbreaks in other animals had largely died out or been eliminated.

Now, Suresh Kuchipudi and Vivek Kapur at Pennsylvania State University and their colleagues have found an astonishingly high rate of infection among white-tailed deer in Iowa. They have been testing 5000 samples taken up to January 2021.

After a third of PCR tests on the first 300 samples came up positive, the researchers decided to make their results public. "This is the first evidence of any free-living wild animal species having widespread SARS-CoV-2 infection," says Kuchipudi (bioRxiv, doi.org/g5x2).

The researchers think what they have found is the tip of the iceberg. It is likely that the coronavirus is common in white-tailed deer across North America, they say, and it will probably keep circulating indefinitely because deer populations have a high turnover rate. The extent of the problem may have gone unnoticed for so long because white-tailed deer show few symptoms when infected. It is quite possible that SARS-CoV-2 is also spreading unnoticed in other wild species elsewhere in the world, says Kapur.

30

million white-tailed deer live in North America

"The search for wildlife reservoirs has not been as comprehensive as one might have hoped," he says. "We could have these effectively silent epidemics and, who knows, pandemics going on among wild species that we are completely unaware of."

SARS-CoV-2 infects a wide range of animals in addition to us. The list includes mustelids such as mink and ferrets, seals, some rodents, cats, dogs and other canids, cows and other ungulates, bats and perhaps even whales and dolphins.

There are two main dangers. Firstly, the more animals that harbour the virus, the more risk there is of other species being infected. In some species, SARS-CoV-2 might be more lethal, which could be bad news for endangered species.

Secondly, if there are animal reservoirs of SARS-CoV-2, there is a risk of new and potentially dangerous variants emerging and jumping back to people. This risk is sometimes exaggerated, however.

While there is some evidence that SARS-CoV-2 mutates more rapidly when it first jumps to a new species, there is no reason to think that the mutations that emerge in other animals will be more dangerous than those constantly occurring in the viruses spreading among humans. As long as SARS-CoV-2 is circulating widely in people, we will remain the most likely source of dangerous new variants such as alpha and delta.

That said, the virus will evolve differently in animal reservoirs. "If it manages to circulate in more than one host, the way it changes becomes twice as complicated," says Kuchipudi.

In the long run, we could end up with a situation like that of flu, which circulates in a number of species, says Kapur. Every now and then, an animal strain jumps to people, sparking a pandemic. ▮

A white-tailed deer in a national park in Tennessee

DANIEL DEMPSTER PHOTOGRAPHY/ALAMY

Psychology

Who sees ‘ghosting’ as OK?

Certain personality types are more comfortable with abruptly cutting ties

Christa Lesté-Lasserre

IF SOMEONE ends a relationship by ghosting – abruptly stopping answering phone calls and messages – it can be very painful for their ex-partner, even when the relationship was short-lived. But according to Peter Jonason at the University of Padua in Italy, such a strategy may seem rational to people with higher scores for the so-called dark triad of personality traits: Machiavellianism, being manipulative and cynical; narcissism, being self-centred or unempathetic; and psychopathy, being socially callous and antagonistic.

“This kind of cold and detached form of break-up – one that doesn’t take anyone else’s feelings into consideration – is an easily reasoned outcome of the way in which these people’s brains work,” he says. “They prefer to just kind of bail.”

Jonason and his colleagues asked 341 volunteers to complete a questionnaire that scored them on their dark triad traits. Participants were asked how much they agreed with statements such as “many group activities tend to be dull without me”, “you should wait for the right time to get back at people” and “I’ll say anything to get what I want”. Volunteers were aged 18 to 72 and were 76 per cent female, 42 per cent undergraduate students and 72 per cent white, the rest being primarily African American.

The team then asked the volunteers to rank how acceptable ghosting is in different situations on a 10-point scale, and say if they had ever ghosted anyone in the past. Higher dark triad scores aligned with a greater acceptance and history of ghosting as a way to end short-term relationships, says Jonason (*Acta Psychologica*, doi.org/g5mf).

That might be related to the fact that people with more dark triad traits are “reward-sensitive” and therefore trying to minimise the painful aspects of life, he says. “So they’re going to try to stay away from the costs of breaking up – which is the drama and the argument.”

“A detached break-up is an easily reasoned outcome of the way these people’s brains work”

“It is not surprising that scales that measure low agreeableness and high antagonism are related to being rude,” says Donald Lynam at Purdue University in Indiana, who wasn’t involved in the study. “Such a person is not connected enough to these [partners] to really care about what they feel or what they think.” He adds that, in general, such self-reporting surveys are reliable.

Long-term relationships are less common in people with dark triad traits, Jonason’s earlier work has shown. But the new study suggests that when they do occur, their partners are unlikely to be ghosted.

“It seems they don’t think it’s acceptable to abandon a long-term partner with blocking on WhatsApp or something like that,” he says. “But [ghosting could] be a way they have of extracting themselves easily from low-investment relationships, which are already known to be the preference of these kinds of people.”

This doesn’t mean people with higher dark triad scores are evil, or even pathological, says Jonason. “These are people who see the world differently for a variety of reasons,” he says. “But we all have these traits in us [to a certain extent], and good and evil is never black and white. To pathologise those people is to essentially dehumanise them and therefore misunderstand them.” ▮

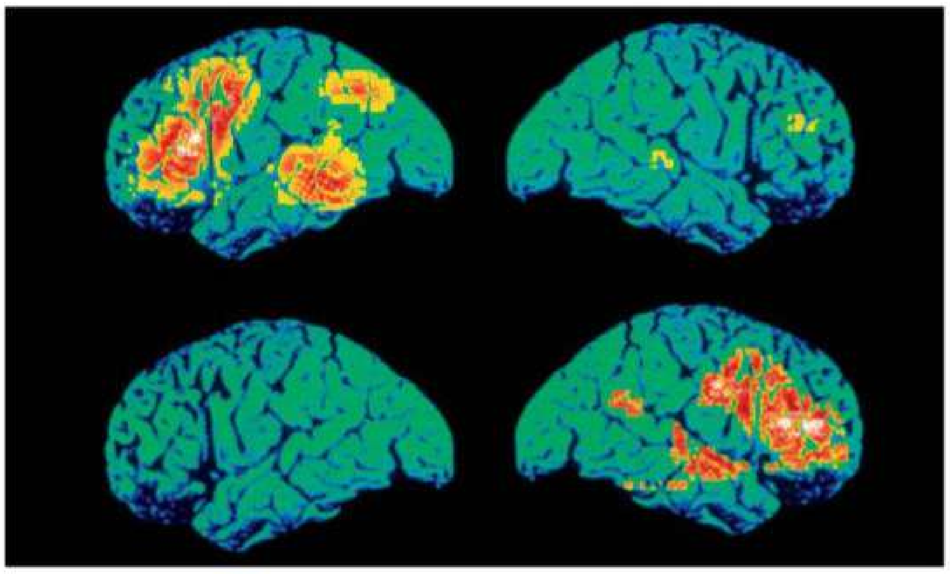
Neuroscience

Using tools can help you grasp language better and vice versa

PRACTISING a tool-using task helps people score higher in a complex language understanding test – and the benefits go the other way too.

Claudio Brozzoli at the National Institute of Health and Medical Research in Lyon, France, and his colleagues asked volunteers to lie in a brain scanner while carrying out tasks involving either tool use or understanding complex sentences.

The tool-based task involved placing small pegs into a tray of holes using pliers. The language test involved understanding sentences such as: “The writer that the poet admires writes the paper.”



WELLCOME CENTRE HUMAN NEUROIMAGING/SPL

Brain areas involved in language comprehension appear as bright patches in a scan

During both tasks, the fMRI machine used to scan participants showed higher activity in the basal ganglia, structures deep in the brain.

New groups of volunteers were then asked to carry out two complex language tests, with half of them doing the pegs and pliers task in between. Their scores on the second language task were, on average, about 30 per cent higher than on the first language task.

The other half of the group did a simpler physical task between the language tests – inserting the pegs with their hands – and their scores on the language test improved only by about 15 per cent on average.

What is more, a language task boosts tool use ability to a similar extent. This was seen if people did two rounds of tool use interspersed with the complex language task (*Science*, doi.org/gnfqqf).

Why might this occur? “Abilities may improve because brain cells in the basal ganglia start working more efficiently and become primed for activity,” says Brozzoli. ▮

Clare Wilson

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Immunology

Pre-existing immunity to covid-19 hints at universal coronavirus vaccine

Michael Le Page

EFFORTS to develop vaccines against a wide range of potentially pandemic-causing coronaviruses have been boosted by the discovery that some people had pre-existing immunity to the SARS-CoV-2 virus amid the first wave of the pandemic.

During the first half of 2020, around 700 healthcare workers in the UK were tested weekly as part of a crowdfunded study called COVIDsortium. Most of these people, who wore protective equipment, never tested positive for covid-19 in PCR tests or developed covid-19 antibodies – proteins that bind to the outside of viruses, preventing cells from being infected.

However, when Leo Swadling and Mala Maini at University College London and their colleagues looked more closely, they found that some of those who tested negative had a protein in their blood that is linked to covid-19 infection, as well as T cell responses to the SARS-CoV-2 virus. It appears these people had what Swadling calls an "abortive infection", where a strong, early T cell response enabled them to get rid of the virus very quickly.

Cells infected by viruses sound the alarm by displaying viral proteins on their surface, and T cells are the immune cells that learn to recognise these proteins and destroy infected cells. While antibodies can only target proteins on the outside of a virus, T cells can learn to recognise any viral proteins.

Many teams are trying to develop jabs that give wider protection

SHUTTERSTOCK/F8 STUDIO

When the researchers looked at early blood samples from people who had an abortive infection, they found that even before being exposed to SARS-CoV-2, they had some T cells that could recognise the proteins that this virus uses to replicate itself inside infected cells (*Nature*, doi.org/gndqs2).

The most likely explanation is that these people were often exposed to the existing human coronaviruses that cause around 10 per cent of colds, says Maini.

The proteins involved in viral replication are very similar in SARS-CoV-2 and other coronaviruses, meaning that if vaccines can be developed that elicit a strong T cell response against these proteins, they should protect against a very broad range of coronaviruses – a so-called universal coronavirus vaccine. One way to do this would be to add mRNAs coding for these proteins to the existing mRNA vaccines that target the virus's external spike protein.

Extra components added to the next generation of coronavirus vaccines might protect both against new variants of SARS-CoV-2 that could evolve and against animal coronaviruses that may jump into people and spark a new pandemic, says Swadling.

"It's a matter of time before another of these members [of the coronavirus family] creates an epidemic or pandemic," says Olga Pleguezuelos at UK-based firm SEEK, whose team is working on a broader coronavirus vaccine.

"If we end up with something that is as infectious as covid and as lethal as MERS, then we are in serious trouble," she says. ▮

Psychology

Imposter syndrome may make you better at your job

PEOPLE with "impostor syndrome", who feel underqualified for their jobs, tend to make better employees because they compensate by striving to be likeable, empathetic and collaborative.

Impostor syndrome is associated with anxiety and low self-esteem. As a consequence, it has long been assumed to hinder work performance. Basima Tewfik at the Massachusetts Institute of Technology measured levels of impostor syndrome among 155 employees at an investment advisory firm in the US. The participants rated their own abilities, while supervisors were asked to rate the participants' performance and interpersonal skills. Those with impostor syndrome were generally rated as having better interpersonal skills than their more confident peers and were considered as competent (*Academy of Management Journal*, doi.org/gm7v4b).

"People with impostor syndrome were basically the ones you'd want to work with," says Tewfik.

In another experiment, Tewfik asked 70 trainee doctors to take the case history of a patient with a migraine or a sexually transmitted infection, played by an actor. Those with impostor syndrome had the same diagnostic accuracy as those without, but were more likely to offer statements recognising the patient's pain, ask follow-up questions, make eye contact, nod, use open hand gestures and speak with a receptive, agreeable tone.

> "People with imposter syndrome were basically the ones you would want to work with"

People with impostor syndrome may have better interpersonal skills because they unconsciously try to compensate for their self-perceived ineptitude by being personable and easy to get along with, says Tewfik. "Maybe it is this silver lining that does actually contribute to success in some respects," she says.

Terry Fitzsimmons at the University of Queensland, Australia, believes impostor syndrome can be positive, but this desire to prove oneself risks leading to stress and overwork, he says. ▮

Alice Klein

Animals

Why barn owls in the British Isles are ghostly white

Jake Buehler

BARN owls are one of the most widely distributed birds, being found on six continents. In Europe, they follow a general pattern: southern areas host pale owls and darker birds dominate in the north. But barn owls in the British Isles are consistently a stark white, and a new analysis explains why.

Ana Paula Machado studied the owls (*Tyto alba*) while at the University of Lausanne in Switzerland. She and her colleagues analysed DNA from 147 barn owls across six European populations. In particular, they were looking for evidence that owls on the British Isles had dark-feathered ancestors and then underwent strong selection for pale feathers. They didn't find any.

"We didn't see that one coming," says Machado, so they began looking for an alternative explanation. She and her colleagues used data on the habitats that barn owls occupy today to predict how they would have been distributed across Europe under ancient climatic conditions. This revealed a now-submerged land corridor of suitable owl habitat along the Bay of Biscay, bridging Iberia and the British Isles some 20,000 years ago (*Molecular Ecology*, doi.org/g5mg).

This suggests owls in the British Isles had pale-feathered ancestors from southern Europe – an idea that fits with the genetic evidence. ▮

White barn owls in the British Isles are related to similar birds in Portugal

SHUTTERSTOCK/ONDREJ PROSICKY

Analysis **Mental health**

Psilocybin steps closer to credibility

Promising results suggest that psychedelic therapies could help some – but not all – treatment-resistant depression, reports **Sam Wong**

COMPASS PATHWAYS

Inside a therapy room used in a clinical trial of psilocybin

IS PSYCHEDELIC medicine finally ready to live up to the hype? Last week, promising results were announced from the largest clinical trial of psilocybin for depression to date. They suggest that, while psilocybin therapy is far from a panacea, it can help some people for whom current medicines are ineffective.

The study was led by Compass Pathways, a UK-based company that holds patents for two synthetic formulations of psilocybin, the active ingredient in magic mushrooms. It involved 233 people with treatment-resistant depression, meaning to be eligible they had to have tried two other treatments without success.

The participants were randomly assigned one of three doses of psilocybin: 1, 10 or 25 milligrams. The 1 milligram dose is considered so small that it is effectively a placebo, but it meant that all participants knew they would get psilocybin, creating an expectation of some benefit. All were given psychological support before, during and after a single dosing session.

In the 25 milligram group, 36.7 per cent of patients had improved depression severity scores three weeks after their dose, and 24.1 per cent were still responding after 12 weeks.

These numbers may seem low: in another trial published earlier this year, 70 per cent of patients who received psilocybin therapy showed a response at six weeks. But that study was smaller and involved two doses of the drug.

> **"We have to avoid overpromising, because psychedelics won't work for everyone"**

"There is a general trend in science that the first small studies have huge effect sizes, and as you study more, they get less and less. The hope that we all have is that it doesn't disappear," says Allan Young at King's College London, who worked on the Compass Pathways study. "We need to do a lot more work looking at the duration of the effect and see how it pans out in the clinic, but the fact that a group has a persistent benefit to 12 weeks, to my mind, is really heartening."

The contrast with conventional antidepressants is stark. People usually need to take daily pills for several weeks before seeing an effect, and if they stop taking them, they risk relapsing.

Psychedelics present an alternative approach. Young suggests people may have a one-off treatment, see a benefit that lasts for weeks or months, then return for occasional top-up treatments if needed.

Depression affects an estimated 264 million people worldwide, many of whom don't benefit from existing treatments. As a result, there is a real need for alternatives, especially ones that lead to fast results.

A form of ketamine, a drug with psychedelic effects but a different mode of action, has already been approved by the US Food and Drug Administration (FDA). Backed by a growing number of pharmaceutical companies and non-profit organisations, psilocybin looks like it could follow.

A trial led by the Usona Institute in Wisconsin involving 100 people with major depressive disorder is due to report results next year. Compass Pathways plans to begin the final stage of its clinical tests in 2022, and the FDA has already designated it a "breakthrough therapy", which could accelerate the approval process.

Taken together, these developments suggest psychedelics could soon be seen as credible mental health treatments, at least for some people. "We have to be cautious about overpromising, because they don't work for everyone," says Celia Morgan at the University of Exeter, UK. "I think they will provide a really important and novel contribution to psychiatry." ▮

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SOLVIN ZANKL/NATUREPL.COM

Ageing

Long-lived fish has genetic clues to extended lifespan

ROCKFISH are among the longest-lived animals we know of, and by studying the natural variation in their lifespans, researchers have discovered key insights into the genetic basis of longevity.

Studies into ageing have traditionally focused on laboratory mice because they are easy to work with. However, Peter Sudmant at the University of California, Berkeley, and his colleagues adopted a different approach, studying longevity in creatures with longer lifespans.

They performed a genomic analysis of 88 species of Pacific Ocean rockfish from the genus *Sebastes* – deep-sea creatures that can live for 200 years – to map out the genetic underpinnings of their lifespans. They accounted for factors such as body size and their environment, which are variables known to affect ageing in many organisms (*Science*, doi.org/g5nh).

"We found genes associated with many different pathways – genes involved in DNA repair, metabolism and immune response," says Sudmant. It is possible that a set of genes called butyrophilins, which are known to influence many human diseases of inflammation, contribute to the extreme lifespan of certain species of rockfish.

Looking into the lives of these animals is critical to learning how to enhance and prolong human health, says Steven Austad at the University of Alabama at Birmingham. "I don't believe we will make much headway in extending human health if we only study short-lived organisms like fruit flies and mice." **Aimee Gabay**

Solar system

Moon chunk may be Earth's space buddy

A SMALL piece of the moon may be orbiting the sun alongside Earth. This object, called Kamoʻoalewa, has an unexpected composition that hints it may have been chipped off the moon and tossed into orbit.

Quasi-satellites like Kamoʻoalewa – of which Earth has five – travel with a planet in similar orbits around the sun. Benjamin Sharkey and Vishnu Reddy at the University of Arizona led a team that used the Large Binocular Telescope and the Lowell Discovery Telescope, both in Arizona, to examine the spectrum of light bouncing off the object. Their observations showed that it was unexpectedly red.

They compared their observations with details of several other types of asteroids that can sometimes be red, including those with a high metal content and those covered in small grains of dust, but none of them tallied. The only close match was with a sample of moon rock brought back by the Apollo missions, hinting that Kamoʻoalewa may have been thrown from the moon in an impact (*Communications Earth & Environment*, doi.org/g5nt).

"It's a kind of missing piece of the puzzle," says Reddy. "We have meteorites on the Earth, we have holes on the moon where some of those rocks came from, and this might be the piece in between."

Determining how long it has been travelling with Earth is a more difficult question. "We think it came off the moon. The composition seems to match, but finding out when it came off the moon or where on the moon it came off of is a tall order," says Reddy. "The only way to do that would be to get a sample back." The Chinese space agency is developing such a mission. **Leah Crane**

Animal behaviour

Our cats can track us just from our voices

PET cats can mentally map their owner's location simply from the sound of their voice.

Previous studies of domestic cats (*Felis catus*) have revealed they can track objects that move out of sight. However, Saho Takagi at Kyoto University in Japan and her team wanted to see how cats track people.

They studied 50 cats, placing each alone in a test room with cameras and with two doors and a window. They placed a speaker outside near one door and a second outside near the second door or window. The two speakers were at least 4 metres apart.

TIM BODDY

During each test, the team used the speakers to play recordings of the cat's owner or a stranger. The voice was played twice, 2.5 seconds apart, and could come from either the same speaker both times or once from each speaker.

Video analysis suggests that cats show little surprise when their owner's voice was played twice from the same speaker, or any time when the stranger's voice was played. But if the owner's voice was played from first one and then the second speaker 4 metres away just a few seconds later, the cats did show signs of surprise.

The authors suggest cats can mentally track their owner's location via their voice, and show surprise when owners suddenly seem to "teleport" to a new place (*PLoS One*, doi.org/g5nr). **Chen Ly**

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Really brief

SHUTTERSTOCK/SRIPFOTO

Strange barrier at Milky Way's centre

The very centre of the Milky Way is devoid of cosmic rays, high-energy particles spewed out by supernovae. Cosmic rays are charged, so a strong magnetic field may prevent them getting close – a phenomenon that happens on a smaller scale in our solar system (*Nature Communications*, doi.org/g5nc).

New UK dinosaur had a bulbous nose

A fresh analysis of dinosaur fossils unearthed on the Isle of Wight, UK, in the 1970s suggests they belong to a new species. This 8-metre-long *Brighstoneus simmondsi* was a close relative of *Iguanodon*, but had a more bulbous nose (*Journal of Systematic Palaeontology*, doi.org/g5nd).

Amazon river dolphin vanishing

One of the last fully freshwater dolphins is disappearing rapidly. A model of population size based on survival and reproductive rates suggests the Amazon river dolphin (*Inia geoffrensis*) will decline 95 per cent in less than 50 years, and may be extinct in a century (*Oryx*, doi.org/g5ng).

Medicine

Gel allows paralysed mice to walk again

A SELF-ASSEMBLING gel injected at the site of spinal cord injuries in paralysed mice has enabled them to walk again after four weeks.

The gel mimics the matrix that is normally found around cells, providing a scaffold that helps cells to grow. It also provides signals that stimulate nerve regeneration.

Samuel Stupp at Northwestern University in Chicago and his team created a material made of protein units, called monomers, that self-assemble into long chains, called supramolecular fibrils, in water.

When they were injected into the spinal cords of mice that were paralysed in the hind legs, these fibrils formed a gel at the site of the injury.

The researchers injected 76 paralysed mice with either the fibrils or a sham treatment made of salt solution a day after the injury. They discovered that the gel enabled paralysed mice to walk by four weeks after the injection, whereas mice given the placebo didn't regain the ability to walk.

The team found the gel helped regenerate the severed ends of neurons and reduced scar tissue at the injury site, which usually forms a barrier to regeneration. The substance also enhanced blood vessel growth, which provided more nutrients to the spinal cord cells (*Science*, doi.org/g5n2).

"It would be very exciting if this finding could translate to humans, though issues of scaling mouse therapies to humans are not trivial," says Ann Rajnicek at the University of Aberdeen, UK. **Carissa Wong**

Languages

FRANK BIENEWALD/ALAMY

Origin of many tongues traced back to ancient millet farmers

FARMERS living 9000 years ago in what is now north-east China may have spoken a proto-Transeurasian language that gave rise to Japanese, Turkish and other modern tongues.

Until now, we assumed the origin lay in the language spoken by nomads in Mongolia 3000 years ago, who didn't farm crops.

However, Martine Robbeets at the Max Planck Institute for the Science of Human History in Germany and her team used linguistic, archaeological and genetic evidence to conclude that it was the onset of millet cultivation (pictured) in what is now China that led to the spread of the language.

The team used linguistic features of the languages and computational analysis to map their spread. This allowed them to trace the proto-Transeurasian tongue back to an area of north-east China around 9000 years ago – the time and place that millet was domesticated.

Genetic data and carbon-dating of millet grains showed that the proto-Transeurasian-speaking population split into communities that started adopting early forms of Japanese, Korean and the Tungusic languages to the east, early forms of Mongolic languages to the north and Turkic to the west (*Nature*, doi.org/g5np). CW

Zoology

Asian honeybees make alarm screams

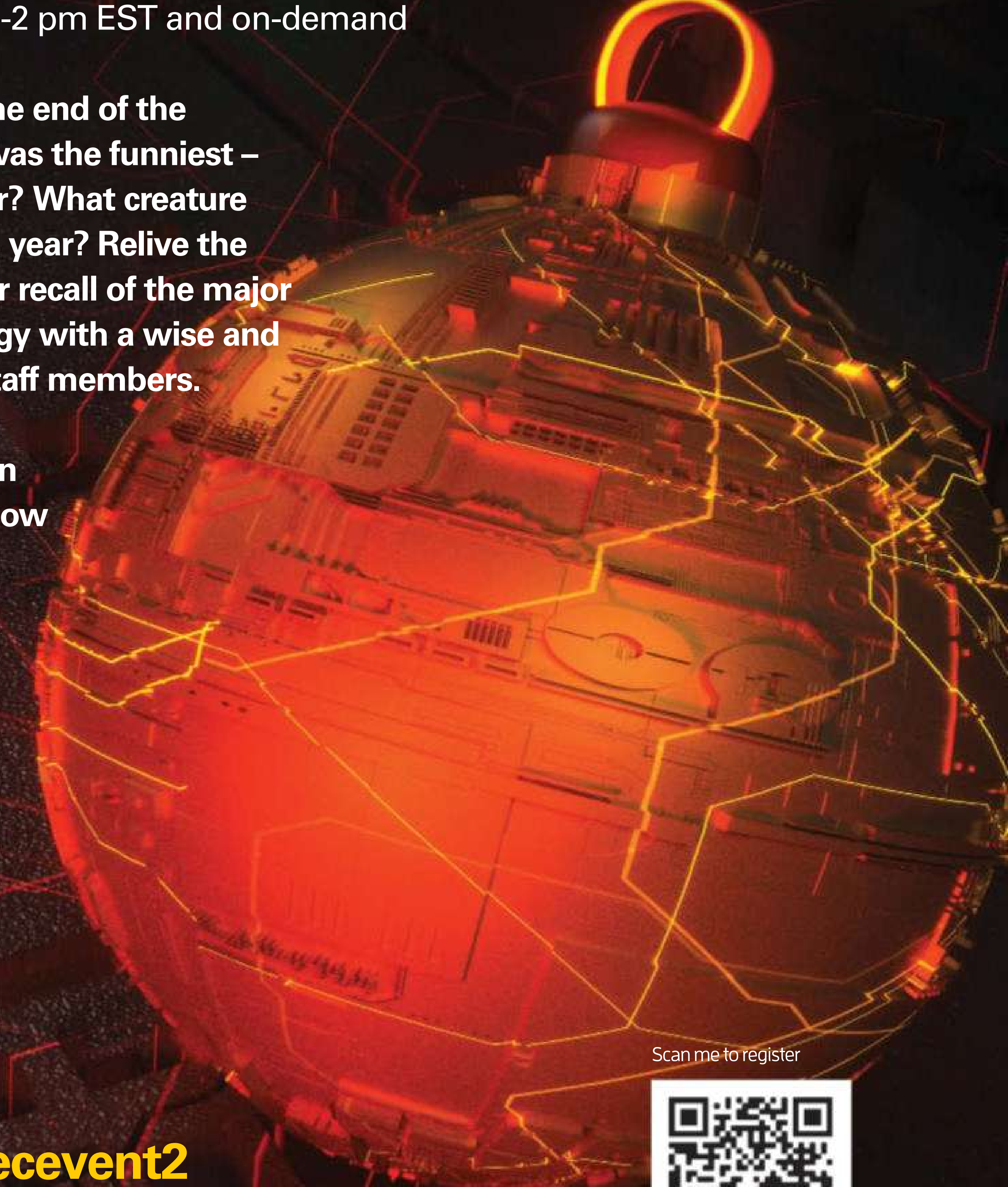
A FRENZIED alarm signal produced by a type of Asian honeybee when giant hornets attack has been discovered.

It was identified by Heather Mattila at Wellesley College, Massachusetts, and her team after recording nearly 30,000 Asian honeybee (*Apis cerana*) signals as their hives were attacked by a species of giant hornet (*Vespa soror*) or a smaller hornet (*Vespa velutina*). Giant hornets are the bees' deadliest predators.

By analysing the sound patterns, the team found that the bees produce harsh, irregular noises that change rapidly in frequency when giant hornets arrive at the hive. The scream-like signals rally more bees to the hive entrance, where they place animal dung to deter the hornets (*Royal Society Open Science*, doi.org/g5nm).

The bees buzz their wings to make the signals, which have acoustic properties similar to alarm shrieks made by primates and birds, says Mattila.

These sounds can convey particular types of threat to other bees in the colony, which "hear" the calls through vibrations in their legs, supporting predator-specific defences. **CW**



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Views

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Global climate action must be just, says **Graham Lawton** p26

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Culture columnist
Jacob Aron prepares an alien world for colonisation p34

Comment

Toxic information

Misinformation about climate change is polluting social media. That's why we have built an AI to try to expose and stop it, says **Bill Posters**

MICHELLE D'URBANO

THERE is a kind of climate pollution that we can't see clearly. It isn't in our rivers, lands or skies, it is in our minds. When climate disinformation goes unchecked, it spreads like wildfire, undermining the existence of climate change and the need for urgent action.

Like the biosphere that sustains us, the health of our information ecosystems is vital to our survival. As an artist, I feel a responsibility to create new ways of seeing the disinformation that has come to define the age of fake news.

Social media sites are honed to grab our attention. Using sophisticated algorithms, the corporations behind them decide what billions of people see around the world, dictated by what keeps you hooked, but also by what the companies paying social media sites choose to put in front of you.

Powerful corporate actors deploy clever influence campaigns via ads targeted at specific users based on what social media firms know about those people. Major oil and gas companies have spent billions of dollars over the years persuading consumers about their green credentials, when only 1 per cent of their expenditure in 2019 was on renewable energy. This is known as corporate greenwashing. Still, fossil fuel firms maintain that their climate policies are "responsible" and "in line with the science".

To expose the scale of corporate greenwashing online, I was part of a team that recently launched Eco-Bot.Net. Co-created with artist Rob "3D" Del Naja of the band Massive Attack and Dale Vince, a green entrepreneur, Eco-Bot.Net's AI-powered website ran throughout the COP26 climate summit, exposing climate change misinformation by releasing a series of data drops for heavily polluting sectors, including energy, agribusiness and aviation.

Academic definitions of climate disinformation and greenwashing were used to unearth posts across Facebook, Instagram and Twitter and visualise them on our website. Eco-Bot.Net then flagged greenwashing ads and posts on the original social media site with a public health warning.

By digging into our data, journalists have already revealed that companies are targeting specific demographics in order to influence public perceptions about climate change – and even alter government policy.

One data drop focused on the 100 biggest fossil fuel producers, companies that have been the source of 71 per cent of global carbon emissions. It found that 16 of these companies ran 1705 greenwashing and climate misinformation ads globally on Facebook and Instagram this year. In total, they spent more than £4 million creating influence campaigns that generated up to 155 million impressions.

Social media companies could end most of the harms from climate disinformation on their platforms if they wanted to. Flagging systems were swiftly introduced to warn users of posts containing disinformation about covid-19. The scientific consensus on human-caused global warming has been resolute for decades, so why can't a similar flagging system be implemented for related disinformation?

It is true that Twitter and Facebook have both introduced climate science information hubs, but these are little more than PR exercises that fail to directly tackle climate disinformation on any kind of scale.

This epidemic of climate change disinformation on social media is eroding collective ideas of truth. The surrealist painter René Magritte saw the purpose of art as one that attempts to "see what is hidden by what we see". In this post-truth age of disinformation, we hope that the public, the press and policy-makers will be able to use our data findings to see what is hidden by what we see online. For the first time, we can witness the endemic scale of corporate greenwashing. The era of climate denial and delay is largely over – except, as Eco-Bot.Net has revealed, on social media. ▮

Bill Posters is an artist and disinformation researcher

No planet B

It’s not a fair COP

To be effective, global action on climate change must be just. That means compensating Indigenous peoples, but also learning from them, writes **Graham Lawton**

Graham Lawton is a staff writer at *New Scientist* and author of *This Book Could Save Your Life*. You can follow him @grahamlawton

Graham’s week

What I’m reading
And Away..., *comedian Bob Mortimer’s autobiography*

What I’m watching
The new season of What We Do in the Shadows

What I’m working on
A ton of ideas and leads from COP26

This column appears monthly. Up next week: Annalee Newitz

MY FIRST few days at the COP26 climate summit felt like an extended metaphor for the state of the planet. I was due to arrive on Sunday, but my train was cancelled because of extreme weather. When I finally got there, chaos reigned and tragedies of the commons were playing out.

The venue in Glasgow, UK, was so overpopulated that accessing sessions was all but impossible. Chairs, tables and wall sockets had sprouted what looked like shanty towns around them as delegates fought to corner scarce resources. Food outlets ran short, bins overflowed and tempers frayed.

But these problems were for the little people. As I searched for my bearings, I was brushed aside by security guards clearing a path for two figures whose body language exuded “VIP”. It was prime ministers Narendra Modi of India and Boris Johnson of the UK, who strode purposefully through the crowds before quickly disappearing into a gated area out of bounds to the plebs.

Amid the disarray, a palpable sense of progress was emerging. However, as the first week wore on, a familiar sense of gloom and despair began to descend. Pledges are easy. Action isn’t. Brazil backtracked on its deforestation promise. Reports that emissions cuts promised thus far would keep warming below 2°C turned out to be so much hot air. I grabbed a word with Gabriel Kpaka of the Sierra Leone Meteorological Agency, who speaks on behalf of the Intergovernmental Panel on Climate Change’s Least Developed Countries Group. He was less than impressed, pointing out that billions pledged to help the poorest countries – often the most affected by climate change though least responsible for emissions and least able to cope – had still not materialised. The pledges were made in 2015.

Another constituency with little to celebrate is Indigenous peoples. They also bear a disproportionate burden of a problem they did little or nothing to create, but to which they hold powerful solutions. According to the United Nations Environment Programme, even though Indigenous peoples make up just 6 per cent of the global population, their lands shelter about 80 per cent of remaining biodiversity. In a sane world, they would be lauded as climate and biodiversity heroes and their advice eagerly sought by the Modis and Johnsons of this world. But all too often they are ignored and marginalised and their lands sacrificed on the altar of the West’s most destructive industries – oil and gas, mining, logging and agribusiness.

> **“Climate change is the latest helping of a grisly gruel of exploitation, colonialism, racism and slavery”**

Depressingly, Indigenous peoples were a marginal presence at COP26, in part because of difficulty in complying with strict covid-19 travel rules, but also because their voices aren’t seen as important. But they were out in force at the Fridays For Future rally that filled the streets of Glasgow with an estimated 25,000 people at the end of the summit’s first week. Greta Thunberg was the headline act and she delivered a powerful (if not entirely fair) rebuke to world leaders. Before she took to the stage, activists from Indigenous communities vented their fury and frustration at inaction and injustice, not just at COP26, but in the years, decades and even centuries preceding it.

We Westerners may sometimes feel angry and powerless in the face of climate inaction, but believe me, we can only dip a toe into the bottomless well of anger and powerlessness felt by many Indigenous peoples. To them, climate change is just the latest helping of a grisly gruel of exploitation, colonialism, racism and slavery that the global north has been serving up to them for centuries.

“We are here today because we know that COP26 won’t do anything,” Namibian activist Ina-Maria Shikongo told the crowd. “They want to continue the massacre that they have been responsible for for hundreds of years already. Your world is built on the blood of our people. You people have to be held accountable for the genocide and ecocide you have been causing. You cannot keep on oppressing our people. You cannot keep on coming to our countries claiming that you are bringing development when all you are bringing is devastation.”

Back in the conference hall, a side event called 10 New Insights In Climate Science warned that to be effective, global action must be just. That means the richest 1 per cent cutting their emissions by a factor of 30 so that the poorest can increase theirs by 50 per cent.

I am writing this before the summit wraps up, so don’t know the final score. But I have little doubt that the justice demanded and deserved by low-income nations and Indigenous peoples won’t be served. On those terms, COP26 will be a failure. But the fight goes on. “We want change,” said Shikongo, to huge cheers. “We want justice. We are tired. We will never give up.” ■

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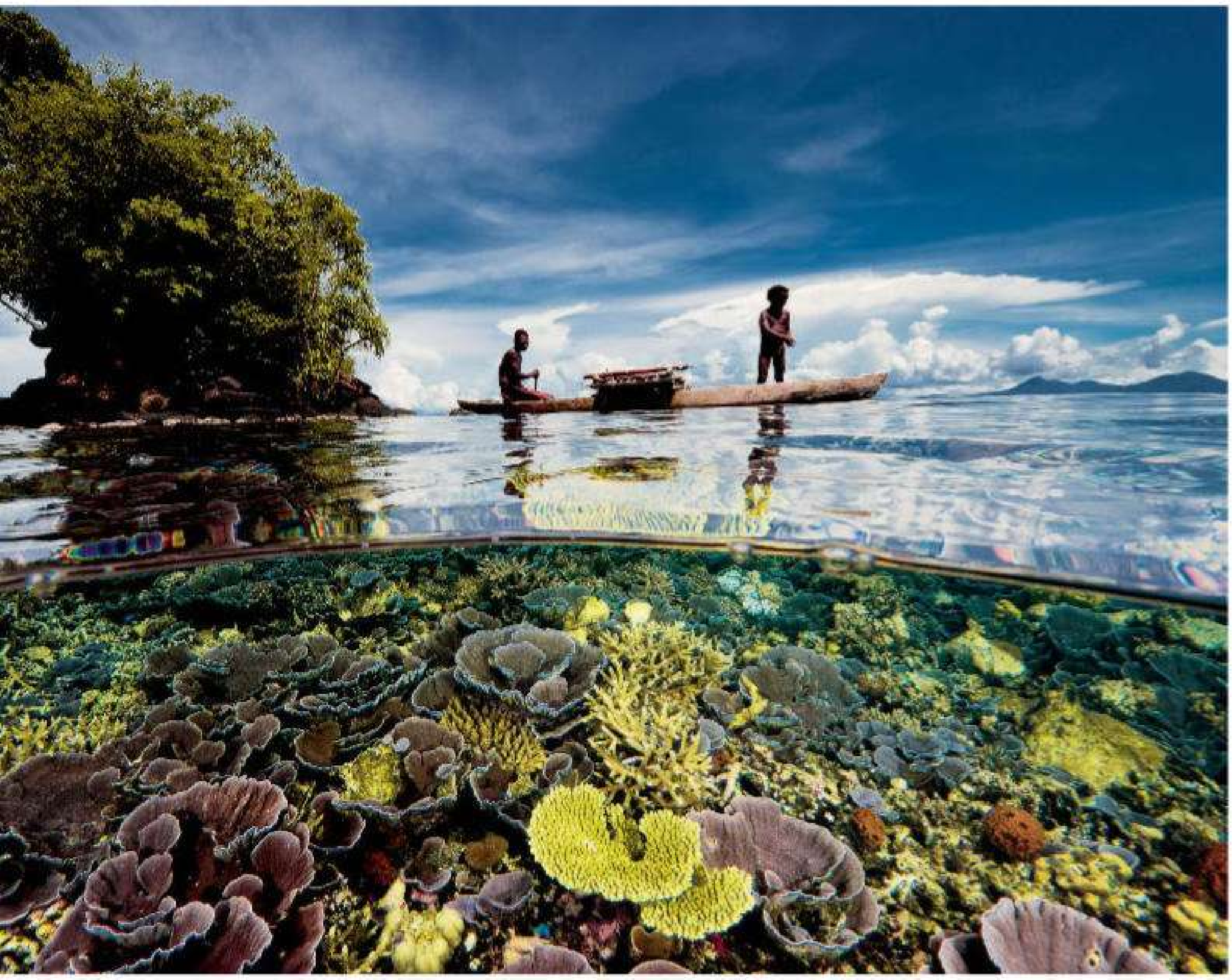

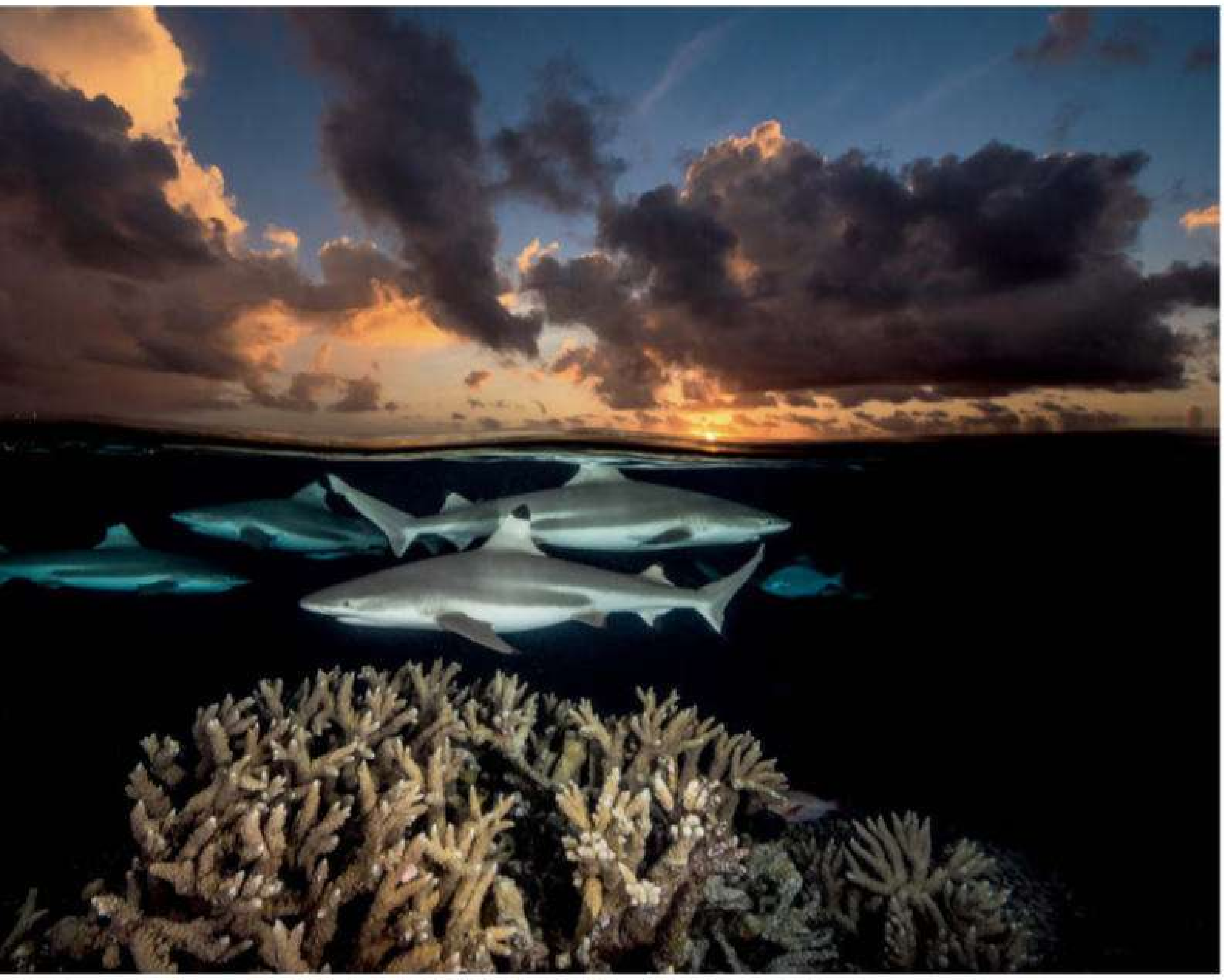

A dual world

Photographer David Doubilet

THESE dazzling shots cross the line between ocean and air, revealing our planet's rich duality. They are taken from *Two Worlds: Above and below the sea*, a photography book by underwater photographer David Doubilet, with essays by Kathleen F. Moran and Kathryn D. Sullivan.

Clockwise from the top left: Doubilet captured the hypnotic hues of a lion's mane jellyfish (*Cyanea capillata*) in Bonne Bay fjord in Gros Morne National Park on Newfoundland, Canada.

Kimbe Bay in Papua New Guinea provides a stunning environment for a father and son as they glide across the water on a fishing boat above a carpet of corals. Part of the Coral Triangle of reef systems in the Pacific Ocean, Kimbe Bay is home to around 400 species of coral.

At sunset on the atoll of Fakarava in French Polynesia, blacktip reef sharks (*Carcharhinus melanopterus*) scout the shallow waters of its South Pass for fish. The pass is 200 metres long and frequented by about 700 of these sharks, making it the highest concentration of blacktips anywhere in the world.

Finally, a grounded iceberg off the shore of Devon Island – the world's largest uninhabited island, thanks to its desert-like climate and rocky terrain – makes for a striking, if fleeting, sight in Nunavut, Canada.

Two Worlds: Above and below the sea is published by Phaidon.

Gege Li

Editor's pick

We'll need to cough up more for climate finance

23 October, p 36

From Terry Cannon,
University of Sussex, UK

You quote Saleemul Huq saying that the $100 billion a year of "climate finance" meant to be pledged to support low-income countries is a "trivial" amount.

He is right. To indicate how trivial, note that the UK government has budgeted half that for its covid-19 test and trace system over two years. Globally, government subsidies and tax breaks to fossil fuel firms come to more than $800 billion annually.

Why is climate finance needed, some of which, incidentally, will be loaned not given? Most adaptation activities rely on public spending as they hold very little interest for the private sector. Adaptation by billions of people on the planet needs several orders of magnitude greater support for finance, which can only be raised by taxation. A carbon tax would be a good start.

Is the entire universe a quantum object?

6 November, p 38

From Andrew Smyth,
Los Angeles, California, US

Your article on quantum reality mentions a "superposition" of states, which means a particle can exist in all possible states at once before it is measured or observed.

Researchers hope to do an experiment on a crystal 100,000 times more massive than used before to demonstrate quantum behaviour to show that this principal of superposition applies to such macroscopic objects. If successful, "is there any reason it stops" there, as Jonathan Halliwell at Imperial College London says.

Maybe the whole universe could exist in a superposition of all possible states? If true, our conscious decisions might be us choosing, instant to instant, which new universe to exist in.

Could this "many worlds" interpretation also explain so-called action at a distance between two paired quantum particles? Perhaps our choice to measure one of these doesn't cause an instantaneous, faster-than-light correlation between the particles. Instead, it instantly puts us in a new universe where these particles are already correlated.

No health-conscious vegan would live on junk food

30 October, p 38

From Robert Sebes,
Sydney, Australia

"The vegan health illusion" doesn't discuss vegan diets in general, only highly processed vegan "junk" food, mainly plant-based meat alternatives.

No health-conscious vegan will live on a diet of these products. Possibly the main consumers are people who have swapped meat-based junk food for vegan junk food. The simple but powerful conclusion reached by Michael Pollan in his book *In Defence of Food* – "Eat food. Not too much. Mostly plants" (but not highly processed fare) – applies equally to omnivores and vegans.

How to solve the space debris problem

30 October, p 42

From Thoby Kennet,
Brighton, East Sussex, UK

Your story on space junk notes that the untrammelled and exponential growth of the number of satellites in Earth orbit, largely for private profit, stacks up problems, known and possibly unknown, for the future.

When once useful artefacts, designed with a limited lifespan in mind, outlive their utility, they are often retired, dismantled and removed to make way for others. The principle has been considered with new buildings as well as in the UK parliament – one new regulation in, two old ones out.

If satellite owners and operators were required to remove from orbit two redundant satellites for each new satellite launched, the overcrowding of Earth orbit would soon be resolved. How long do we have to wait for a simple and obvious solution like this to be adopted, and does the global political will extend to suspending commercial satellite launches until further notice?

Wind farms should tap the power of tides as well

16 October, p 12

From Ken Russell, Aberdeen, UK

Your picture of offshore wind turbines shows an interesting phenomenon. At the time the image was taken, the tide must have been running from right to left, as verified by the turbulent wake at the base of each turbine. Has anyone thought of retrofitting water turbines to the base of each wind turbine? This would be cheap, since infrastructure is in place. Also, tidal power will continue to be produced even when the wind doesn't blow.

Let's take this carbon credits idea even further

23 October, p 26

From Roger Gifford, Queanbeyan, New South Wales, Australia

Graham Lawton suggests the time may be ripe to introduce tradeable "personal carbon allowances" to ration greenhouse gas emissions incurred by our spending. It is also ripe for broadening this concept.

Besides climate change, other global environmental onslaughts are beyond the reach of market forces alone to address: toxic chemicals entering the air, water and land, the loss of top soil to the oceans faster than soil formation, a sixth mass extinction event, the spread of waste plastic everywhere.

A composite personal environmental impact ration could address this by varying the unit cost in these annual rations forfeited for each purchase. It would allow people to choose where their activities impact the global environment while capping the community's overall environmental damage.

I studied this idea decades ago, but it would have been technically cumbersome to administer then. Current methods and technology make it much more practicable.

Consciousness is just the brain filling in the blanks

4 September, p 44

From Ralf Buckley, Griffith University, Queensland, Australia

Models of consciousness that you detail don't explain why evolution of biological information processing should create conscious subjective experience.

One possibility is that subjective experience is a mechanism for continuity of processing under a biological constraint – the timescale of transmission across synapses. This is substantially slower than the speed at which sensory inputs can change.

Perhaps, therefore, brains create a semi-stable working approximation, and modify only the portions that change. That approximation, I suggest, is our conscious subjective experience. ■

For the record

■ **The five graphs in "Who is tackling climate change best?" (30 October, p 10) should have stated emissions in millions of tonnes of CO_2 equivalent.**

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On a (natural) high

Humans aren't alone in their love of mind-altering substances. All manner of creatures get wasted from time to time, finds **George Bass**

Book
Drunk Flies and Stoned Dolphins: A trip through the world of animal intoxication
Oné R. Pagán
BenBella Books

IF YOU have ever woken up with an apocalyptic hangover and vowed to live a more wholesome life, don't look to nature for inspiration. In particular, don't copy the cedar waxwing bird. Its penchant for the fermented fruit of the Brazilian pepper tree has led to wonky flights and window-collision fatalities with a blood-alcohol concentration of almost 0.1 per cent (the limit when driving in the US is 0.08 per cent).

In *Drunk Flies and Stoned Dolphins*, biologist Oné R. Pagán leads us through the history of animal intoxication, while making it clear that he isn't "advocating for the consumption of drugs… not even a little".

He begins with the most widespread drug of all: alcohol. Naturalists have noted its effect on wildlife for centuries, with Charles Darwin recording in *The Descent of Man* how baboons in north-east Africa could be lured into a trap using beer. He also noted how, after being plied with brandy, a spider monkey "would never touch it again, and thus was wiser than many men".

Pagán writes in a personable style and with a boyish enthusiasm for his subject. He wants to invite the reader on a journey that he firmly believes "is no less awe-inspiring than a trip to the stars".

We learn that pods of rough-toothed dolphins have been seen passing around pufferfish in the manner of cannabis users sharing a joint. Zoologists believe the fish's lethal tetrodotoxin induces psychoactive effects, which the dolphins seem to enjoy.

Bees, however, are less liberal. Any workers returning to the hive while drunk on fermented nectar are forbidden from entering, and are sometimes executed at the entrance by dismemberment.

The book also explores non-recreational drug use by animals, explaining the many reasons why they use them. Sometimes it is medicinal, such as the Arctic fish that produce metabolic ethanol to endure freezing temperatures; sometimes it is an evolutionary accident, as with the observation that monkeys drawn to alcohol "conferred a selective advantage on our primate ancestors by helping them locate nutritious fruit at the peak of ripeness".

> **"Dolphins have been seen passing around pufferfish in the manner of cannabis users sharing a joint"**

And sometimes it isn't clear if the intoxication is deliberate or something the animal may come to regret. Examples include jaguars that eat leaves of the yagé vine (an active ingredient in ayahuasca hallucinogenic tea) and become unusually playful, and mid-18th-century horses that became dangerously erratic after eating locoweed during droughts.

Drunk Flies and Stoned Dolphins is more than just a blooper real of animal overindulgences, however. Pagán illustrates that, while human history has been shaped by trade (which was itself steered by the popular stimulants and depressives of the ages), animals' relationships with drugs are no less complicated.

He also reveals how animals have helped us understand the biological effects of intoxication via experiments on fruit flies. Measuring drunkenness in a fly requires a device called an "inebriometer", a tube filled with ethanol vapour that lets scientists record the dizziness of the sozzled insect. Tests like these have revealed that the flies' habituation, tolerance and reward behaviours are surprisingly similar to our own. Pagán also makes space to discuss addiction, and how it could happen to any multicellular organism with a nervous system.

Then there are the potential effects of drug pollution on wildlife. In 2019, a person in Tennessee flushed a stash of drugs into the sewers, prompting the local police to jokingly warn the public about the risks of hyper-aggressive "meth-gators" (this was later deemed to be scientifically unlikely).

Talking of myths, we discover the truth behind the idea that Santa's flying sleigh was first seen by Sámi people who had imbibed reindeer urine tainted with psychedelic mushrooms. Once you have read *Drunk Flies and Stoned Dolphins*, you suspect that Rudolph could well ignore the carrot you leave out for him this Christmas, and instead tuck into the boss's whisky. ■

George Bass is a writer based in Kent, UK

SHUTTERSTOCK/ANDREA IZZOTTI

Is there a chemical explanation for those chilled-out smiles?

Running from the storm

A road trip with a robot and a dog is less fun than it sounds, even with Tom Hanks at the wheel, finds **Gregory Wakeman**

Film
Finch
Miguel Sapochnik
Apple TV+

APPLE TV

Tom Hanks plays Finch, whose post-apocalyptic journey depends on a flawed, yet loyal, team

FINCH has all the elements to be a dark, but ultimately uplifting, post-apocalyptic, sci-fi comedy drama. Not only does it boast Robert Zemeckis as a producer, it also comes from Steven Spielberg's studio Amblin Entertainment and marks the second feature film of Miguel Sapochnik, who directed key parts of the iconic HBO series *Game of Thrones*.

The primary reason it should captivate audiences throughout, though, is that Tom Hanks plays the title character. Hanks is in pretty much every scene as Finch, an ailing inventor who is the last person on Earth. Since he still has his trusty and beloved dog Goodyear by his side, Finch decides to build an android named Jeff to look after his companion once he is gone.

But after learning of an impending storm that is going to destroy his home, Finch decides to leave St Louis, Missouri, and drive Jeff and Goodyear across the US to San Francisco in his run-down motorhome.

Along the way, Finch tries to teach his constantly malfunctioning robot what it means to be human so that he can truly protect Goodyear, all while trying to find food and safety in the dangerous and ravaged post-apocalyptic world.

Unfortunately for Hanks fans, *Finch* never actually comes close to delivering on its potential. While Sapochnik is able to create impressively menacing visuals of enormous storm clouds wreaking havoc, this feeling of peril quickly dissipates. Once gone, it never returns, as there aren't enough set pieces to make you sit up, let alone put you on the edge of your seat.

At the same time, while the reasons for the destruction of civilisation are heavily teased, Sapochnik's direction and Craig Luck and Ivor Powell's script lack the detail or weight to really make the film's message about the dangers of climate change connect.

The main reason why *Finch* falls so short, though, is that the camaraderie and relationship between Finch, Jeff and Goodyear doesn't come close to resonating. Since Finch is struggling with illness, Hanks's portrayal is rightfully timid and frail. But this means he never manages to bring out the humanity of the character, who spends most of the film either coughing up blood or getting annoyed at Jeff.

Somehow, Hanks was able to develop a more emotional connection with a volleyball covered in blood in Zemeckis's 2000 survival drama *Cast Away* than he is with Jeff and Goodyear. *Finch* was clearly inspired by that film, as well as Spielberg's repeated use of science fiction to explore fatherhood. But it doesn't add anything to the genre or explore the theme in an insightful manner.

It also doesn't help that Caleb Landry Jones's vocal performance as Jeff is too flat. As a result, the repeated attempts at comedy fail. Instead, we are forced to endure scenes of Jeff falling over or misreading situations because he takes things too literally. All of which quickly becomes tiresome.

Despite all this, *Finch* isn't a complete miss. The score from Gustavo Santaolalla is particularly rousing, while Sapochnik and his editor Tim Porter make sure that there is a steady pace that averts a full descent into tedium. Jo Willems's cinematography glistens, too. It perfectly complements Sapochnik's framing, which means that a lot of the shots are utterly gorgeous.

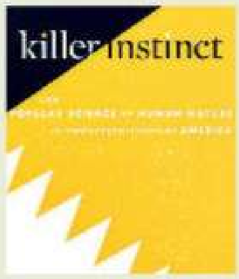
It is just a shame that *Finch* doesn't actually do anything more heartfelt and thought-provoking with these images. Instead, it is the cinematic definition of style over substance and is ultimately so disappointingly tame that not even the star power of Hanks can salvage it. ▮

Gregory Wakeman is a journalist based in Los Angeles

Don't miss

Watch

Star Trek: Discovery sees the crew of the Discovery propelled 1000 years into their future where they must, once again, save the galaxy. Season 4 runs from 18 November on Paramount+ and 19 November on Netflix UK.



Read

Killer Instinct is historian Nadine Weidman's account of how 20th-century arguments about nature versus nurture came to dominate how we think about behaviour, and how this has hindered our understanding of who we really are.

Watch

Back to Earth has artist and astronaut Nicole Stott sharing her experiences aboard the International Space Station. Her talk at London's Royal Institution will be live-streamed at 7pm GMT on 24 November.

NETFLIX; NASA JOHNSON

The games column

Mine, build, kill some aliens Strategy, supply chain challenges and the perils of colonising an inhospitable planet add up to make *The Riftbreaker* one of the most fun games of the year so far, says **Jacob Aron**

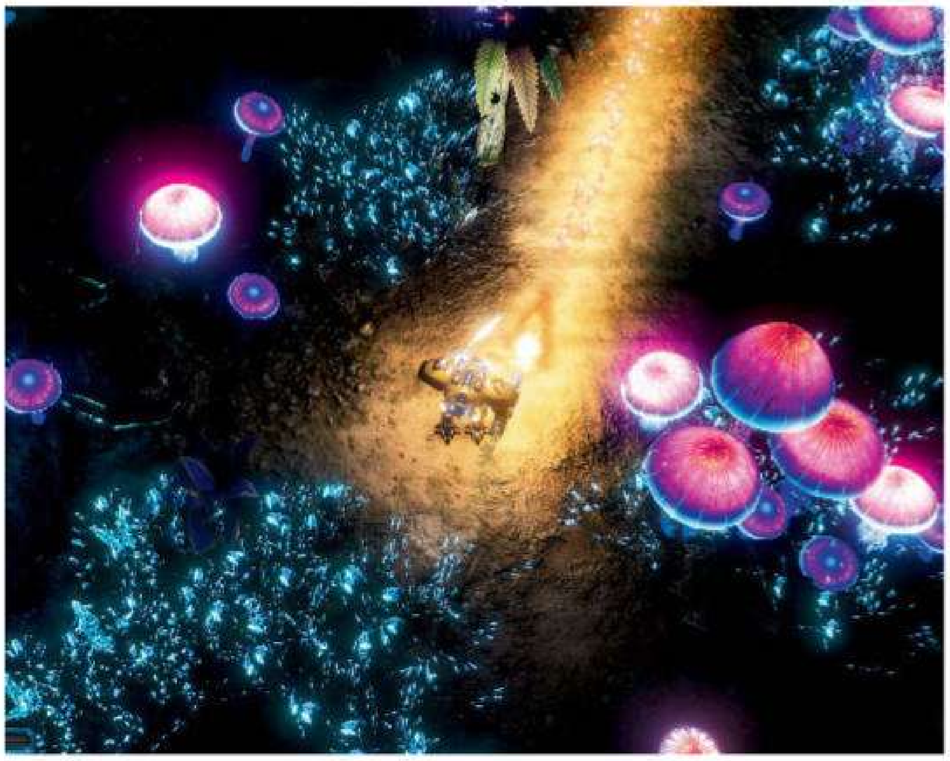
Jacob Aron is *New Scientist*'s deputy news editor. Follow him on Twitter @jjaron

Game
The Riftbreaker
Exor Studios
PC, PlayStation 4 and 5, Xbox One and Series X/S

Jacob also recommends...

Games
StarCraft
Blizzard Entertainment
PC
Still one of the best real-time strategy games ever made (and practically a national sport in South Korea), its Zerg are a clear inspiration for The Riftbreaker*'s aliens.*

Geometry Wars: Retro Evolved 2
Bizarre Creations
Xbox 360
My favourite twin-stick shooter pits you against simple geometric shapes in a whirling maelstrom of majestic neon chaos.



EXOR STUDIOS

In *The Riftbreaker*, you scout an alien world and prepare it for colonisation

WHEN writing this column, I try to remember that many of *New Scientist*'s readers don't play video games. With that in mind, I try to pick titles that have something to say about science or technology but don't require knowledge of gamer terminology. This month, I have failed, but stick with me while I tell you about one of the most entertaining games I have played this year.

The Riftbreaker casts you as Ashley Nowak, an explorer sent on a one-way trip to the distant planet of Galatea 37. Really, you play as her hulking mech suit, dubbed Mr Riggs. The story is paper-thin – there is a brief mention of Earth being uninhabitable after the "Yellowstone event", presumably a reference to the potentially apocalyptic supervolcano in Wyoming. Your job is to survey the planet, construct a "rift gate" to enable teleportation back to Earth and to prepare Galatea 37 for colonisation.

It all starts fairly simply, as you set up wind turbines and solar panels to power automated mines and gather resources. But then you come under attack from the local animals – overwhelming hordes of reptilian beasties. Mr Riggs is bristling with weapons to defend yourself. You can also set up walls and turrets to build a defensible base. Then there are the natural disasters, such as earthquakes and meteor strikes, and bad weather that interferes with your power generation.

> **"Before you know it, you are chasing supply bottlenecks while occasionally pausing to mow down aliens"**

This loop – gather resources, improve your weapons and your base and defend yourself – propels the entire game, deftly blending two genres known as real-time strategy (RTS) and twin-stick shooters. The former usually involves building up an army and smashing it into another until one of you is wiped off the map. The latter is about controlling a character and ducking out of the way of enemies as you try to take them down.

Combining these genres is a pretty weird idea, but *The Riftbreaker* really makes it work, as your base and Mr Riggs work in tandem to hold back the aliens. What I particularly like about *The Riftbreaker* is that, unlike mission-based RTS games such as genre classics *StarCraft* or *Command & Conquer*, your base persists throughout the entire game, meaning it grows into a sprawling behemoth. I occasionally found myself stumbling across sections that I had built hours earlier and had completely forgotten about.

As you grow your base, the game introduces another concept that regular readers will know I am a big fan of: supply chains. While your initial buildings are made of easily available carbon and iron (or "carbonium" and "ironium" as the game strangely calls them), building the rift gate requires rarer materials such as uranium and cobalt that can only be found by visiting other areas of Galatea 37 and setting up outposts, which in turn need supplying. Before you know it, you are chasing the bottlenecks in your system while occasionally pausing to mow down aliens. It is as if Ellen Ripley got a side gig as a logistics manager.

While playing, I did wonder if I should feel bad about strip-mining an entire planet. This point is touched on with a few lines of dialogue, and while you can choose to use only solar, wind, biomass or geothermal power throughout the game and receive a "going green" achievement for doing so, burning your way through the biosphere is too much fun to miss. ▮

World Pancreatic Cancer Day

Read more at **healthawareness.co.uk**

The London Clinic is the first hospital in the UK to employ OncoSil™, a breakthrough treatment for locally advanced pancreatic cancer. The treatment is not yet available on the NHS.

There is an urgent need for new **pancreatic cancer treatments**

There were 10,000 pancreatic cancer cases in the UK annually in 2018 and increasing in incidence. It remains difficult to diagnose, so usually presents late with limited treatment options.[1]

Typically seen in later life, common symptoms include jaundice, weight loss or severe pain - often mimicking back pain. Early diagnosis is important according to Dr Harpreet S Wasan, Consultant and Reader in Oncology at Hammersmith Hospital, London. "Only about 10% of patients diagnosed with pancreatic cancer can be operated on, even with early diagnosis surgery may not be an option as tumours quickly start attaching to major surrounding blood vessels. In cases where the disease has become advanced, options are limited to systemic chemotherapy."

> *Only about 10% of patients diagnosed with pancreatic cancer can be operated on, even with early diagnosis surgery may not be an option as tumours quickly start attaching to major surrounding blood vessels.*

This bleak outlook has persisted for some time, but a recent clinical trial offers oncologists a potential new addition to their therapeutic toolkit. A pilot study investigated the safety of the OncoSil™ device which allows for the implantation of radioactive microparticles, delivering a high dose of radiotherapy directly into pancreatic tumours. Other advantages of the interventional procedure include speed, efficiency and less risk to organs surrounding the pancreas. The one-day procedure is also convenient for patients.

Although the UK has well-organised cancer networks and specialist pancreatic cancer centres, there is currently no approval of, or funding for, the procedure to be used in the NHS despite its potential and its approval as a device by the BSI (British Standards Institution).

References

1. https://www.cancerresearchuk.org/health-professional/cancer-statistics/statistics-by-cancer-type/pancreatic-cancer [last accessed Nov 21]

Dr Harpreet S Wasan
Consultant & Reader in (Medical) Oncology Lead for Medical Oncology & Clinical Divisional Lead for Cancer for N.W London Research Network Department of Cancer Medicine Hammersmith Hospital, Imperial College Healthcare NHS Trust

Nuclear medicine is offering innovative therapies for pancreatic cancer

Research and investment into nuclear medicine has been gathering pace over the last decade and is developing some promising options for pancreatic cancer patients.

An alignment of science, research, funding and innovation has resulted in an acceleration of radionuclide therapy for both diagnosis and treatment of cancer, says Zarni Win, Consultant Radiologist at the London Clinic. The potential of harnessing radioactive substances to treat cancer has taken off in the last five years. "Both large and small pharma companies have identified a lack of options for pancreatic cancer and have really got behind it with funding and innovation."

> *Both large and small pharma companies have identified a lack of options for pancreatic cancer and have really got behind it with funding and innovation.*

Pancreatic cancer patients will benefit from these new developments, says Dr Win. "People tend to present too late once the cancer has spread and options for surgery are limited. Chemotherapy and radiotherapy are not targeted in the same way as therapies such as Oncosil ™ which deliver the treatment directly, in a single sitting, without the side effects of conventional treatments."

The desired outcome is that patients become eligible to undergo surgery. A recent clinical trial showed that 33% of participants became candidates for surgery compared to 10% with conventional treatment.

The London Clinic was the first site in the UK to offer the Oncosil ™ procedure and Dr Win is optimistic that this 'game changing' therapy will soon be available on the NHS.

Dr Zarni Win
Consultant Radiologist and Nuclear Medicine Physician, Head of Service Nuclear Medicine, Imperial College Healthcare NHS Trust

Pancreatic cancer: the cancer that has been left behind

Awareness and early diagnosis are vital to improve outcomes for people with pancreatic cancer.

Compared to other cancers, pancreatic cancer presents challenges for both patients and doctors due to its low survival rate and limited treatment options especially if the disease is diagnosed later. Layla Stephen of the cancer charity PLANETS describes it as "the cancer that's been left behind." She says: "The speed at which you can lose pancreatic patients is one of the biggest things, particularly nowadays when many other cancers are becoming more treatable."

> *No matter what age you are, if you feel unusual pain or something changes you must get it checked out straight away.*

Layla describes the treatment journey for pancreatic cancer as fairly straightforward but dependent on the stage at which it is diagnosed. Earlier stage cancer can be treated with surgery, radio or chemotherapy or a combination. Research on detecting pancreatic cancer earlier is key to improving survival as well as discovering new or improved treatment options such as Intra-operative radiotherapy, Radiation therapy and Immunotherapy and which we, as a charity, are actively involved in supporting.

With early diagnosis key to longer term survival, Layla's advice is to seek help. "No matter what age you are, if you feel unusual pain or something changes you must get it checked out straight away."

Whilst research into pancreatic cancer moves forwards, it remains a difficult disease to manage and specialist support from health charities is particularly valuable.

Layla Stephen
CEO, PLANETS

PAGE WRITTEN BY
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THIS IS AN INDEPENDENT SPREAD BY **MEDIAPLANET** WHO TAKE SOLE RESPONSIBILITY FOR ITS CONTENT

TELL ME WHY

Ours are enquiring minds, primed to ask "why?". Luckily for us, we live in a universe that gives us answers.

Sometimes. In this special issue to celebrate *New Scientist*'s 65th anniversary, we poke at 13 "whys" about ourselves, the cosmos and our place in it that take us to the very edge of our understanding – questions as enigmatic, and sometimes more so, as they were when this magazine first appeared

01 Why is there something rather than nothing?

“NO QUESTION is more sublime than why there is a Universe: why there is anything rather than nothing,” philosopher Derek Parfit once wrote.

Sublime it might be, but the question has traditionally exercised philosophers and theologians. Creation myths, a feature of many cultures, satisfied a deep-seated need for meaning and narrative drive in our existence (see “Why do we exist?”, overleaf). Scientific thought, insofar as it paid attention to such matters, assumed the cosmos had always been there in an eternal, unchanging state.

Then came the greatest scientific revelation of the past century, arguably of all time: what came to be known as the big bang.

Its seeds were sown by Albert Einstein with general relativity, his theory of gravity, back in 1915, and by Edwin Hubble and others in the 1920s. Their astronomical measurements showed that far-off galaxies were receding from us, as if the universe were expanding.

As late as the 1940s, physicists including Hermann Bondi, Thomas Gold and Fred Hoyle were explaining these observations in terms of an eternal, steady state universe that expanded through the continuous creation of matter. Today, we can cross this possibility off the list. “That’s not a stable state for a universe that is structured in the way we see ours is,” says cosmologist Katie Mack at North Carolina State University.

That is partly because it is hard to square with the way gravity works, only pulling inwards, not pushing outwards. But it is mainly down to the discovery of the cosmic microwave background radiation in the 1960s. This all-pervasive radiation was exactly what you would expect to see if everything began as a tiny, dense glob of matter and energy that has since expanded and cooled to become the universe we see.

Suddenly, the “why something rather than nothing?” ball was firmly in science’s court. What exactly happened at the instant of the big bang, now pinpointed to some 13.8 billion years ago?

These days, cosmologists don’t automatically think of it as a point when everything came into being from nothing, says Mack. Indeed, while we are confident we have got the story of cosmic evolution broadly right back until that point, the big bang “singularity” is singularly problematic. It represents the point at which general relativity’s equations become plagued with ungovernable infinites, and break down. In this sense, “the big bang is understood as not a fact, but a problem”, says cosmologist Daniele Oriti at Ludwig Maximilians University in Munich, Germany. “It’s a pathology of our theories.”

With no clear explanation of what the big bang was, we are pretty hamstrung in explaining why it was. There is no shortage of ideas: that our observable universe is just one of many budding off one another in an eternally inflating multiverse (see “Why is the universe just right?”, page 41), for example, or that a pre-existing universe contracted to a small, but not infinitesimal, size, before bouncing outwards again. Oriti is developing an idea in which the big bang singularity represents a “phase change” where space and time, and the rules of geometry that govern our universe, emerged from some non-geometric netherworld.

But in explaining how our something sprung from something else, these resolutions just raise the question of why those other things existed. Perhaps that is telling us something about what it means to seek the origins of everything in the first place. The truly sublime aspect of asking this question isn’t so much in finding the answer, but in the otherworldly journey it takes our minds on. **Joshua Howgego**

02

Why do we exist?

WE CAN attempt to answer the question of why we exist in a literal sense: by tracing our human story back through the whorls and rifts of evolution, through the contested origins of life on Earth and the collapsing cloud of dust and gas that became our home planet 4.5 billion years ago, back to the birth of our universe some 13.8 billion years ago – and perhaps further still (see "Why is there something rather than nothing?", previous page).

Yet none of this story of happenstance helps us in finding the kind of meaning we crave: meaning in significance. "Now we know that the cosmos contains at least a million billion galaxies, each containing hundreds of billions of stars, most of which have planets around them. In one of these zillions of planets, as probably in many others, chemistry became complex and evolved in all sorts of critters, one of which, not particularly good in surviving, is humankind," says physicist Carlo Rovelli at Aix-Marseille University in France. "It is clear that any ambition of this humankind to be particularly significant in the grand scheme of things looks silly."

That realisation was certainly a big deal when it first brought gods and mythologies we created crashing down, says Victor Strecher, who studies the importance of purpose for our well-being at the University of Michigan. That started in earnest in the 1700s, as scientific inquiry began to upend our assumptions about our central place in the universe. Simultaneously, the industrial revolution first saw people leaving long-established rural communities and venturing out into a wider world in large numbers.

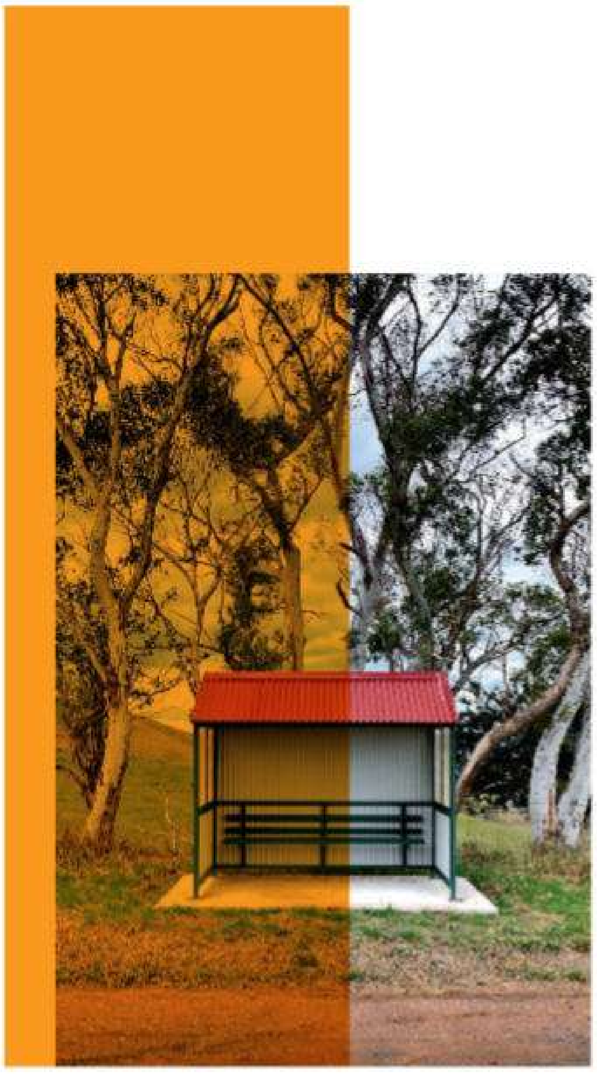
The mistake, says Rovelli, is to tether our search for meaning to our cosmic importance. "Our marginality in the cosmos does not diminish our significance for ourselves at all," he says. The point of existence becomes to find – or make – meaning with the improbable bit of life we have been given, something humans are particularly skilled at. "We are ourselves sources of meaning, desires, thirsts," says Rovelli. "And we are so because evolution designed us this way."

Philosopher Albert Camus concluded something similar after some serious grappling with the subject, says Strecher. Like Sisyphus forever rolling a boulder uphill, our tiny lives may seem pointless – but as long as we are driven by pursuit of our own purpose, it can all work out. As Camus put it: "One must imagine Sisyphus happy."

The question of what it all means may have particular weight at this moment in human history, says Strecher, not just because of our growing cosmic understanding, but also because we are pushing back the length of human lives. "A year is not a year is not a year," he says. "Life has meaning because it is limited." If we start to extend people's lifespans to 150 or 200 years, we need to also think about how to ensure those will be worthwhile years imbued with purpose.

How do we find a sense of purpose if we are lacking one? It needn't be a superhuman aim, says Strecher – you should think of it as a goal built around the things you value most. "If they mean zero in the big picture of the universe, who gives a shit?" he says.

Tiffany O'Callaghan



JOHN CLUTTERBUCK/GETTY IMAGES

Humans are skilled at finding meaning in the mundane

03

Why does evolution happen?

EVOLUTION is a fact of life, at least of life as we know it. Here on Earth, organisms that just so happen to be better adapted, or "fit", for their environment, perhaps by virtue of a fortuitous mutation, tend to survive longer and leave more offspring. The less fit leave fewer descendants and the unfit none at all. Whatever it was that made the winners fit thus accumulates in the next generation, a cruel and random Squid Game called evolution by natural selection.

As to why it happens, on one level that's simple. According to biologist Richard Dawkins, evolution is simply a change in gene frequencies in populations. If a gene in a colony of woodlice living under a dead log becomes more or less common for some reason, evolution has happened.

But must it be like that? All life on Earth that we know of comes from the same origin and uses the same biochemical operating system based on DNA. Putative life on other planets, or "shadow life" from an independent origin on Earth, might conceivably operate under very different rules. Does life have to evolve – and if so, does that have to be by natural selection? "That's a very interesting and large question," says Dawkins.

Arik Kershenbaum at the University of Cambridge, author of *The Zoologist's Guide to the Galaxy: What animals on Earth reveal about aliens – and ourselves*, thinks the alternatives are limited. One might be to postulate an intelligent designer, as perhaps we ourselves might someday design self-replicating organisms. But that only gets you so far, says Kershenbaum. "It's definitely a possibility we could find planets covered in artificial life," he says. "But then you have to explain where the designers, the original life, came from."

And in that recursion, you hit the nub of the matter. "Essentially, the mechanism by which life arises is accumulation of complexity, and that complexity doesn't come from nowhere and it can't arise by chance," says Kershenbaum. Purely thermodynamically, it must arise step by step.

The spontaneous, sustained accumulation of complexity in a system requires three things to be present. There must be variation, to give raw material for change in the first place; there must be differences in fitness, to give an advantage to change; and there must be heritability, to consolidate and pass on change over time. These three things are nothing more than the preconditions for natural selection – and wherever they come together, natural selection inevitably follows.

The operating system itself matters not a jot. "The biology is irrelevant," says Kershenbaum. "It doesn't matter what the biochemistry is, it doesn't matter if it's silicon-based or methane-based." Even if a different type of life got going, it is hard to see how it could persist without mutation and selection to make it fitter and provide resilience to slate-wiping events in a world that is itself dynamic and changing. Kershenbaum proposes that evolution is a law of nature, a bit like gravity. Where there is life to ask the question, there is evolution. **Graham Lawton**

04

Why does time only move forwards?

BY THE time you have finished reading this, you will be a couple of minutes older. Hopefully you won't regret those minutes, because you can't get them back. Time, as we all know, only moves in one direction for us. The question of why, however, doesn't come with a simple answer.

Searching for time's arrow in the underlying, microscopic laws of physics certainly draws a blank. They give us no reason to think atoms, molecules and so on can't move backwards as well as forwards in time, much as they (and we) move freely in three dimensions of space. The laws don't differentiate between past, present and future, or between cause and effect.

"That distinction only becomes relevant in the macroscopic world, where our incomplete information about the precise physical configuration of a system leads us to perceive an arrow of time, and to put causes first and effects after," says physicist Sean Carroll at the ›

California Institute of Technology.

At issue here is the concept of entropy. This is a measure of the amount of disorder in a system, defined as the number of different microscopic configurations it can have without changing its macroscopic, or overall, appearance. A box of hot gas has high entropy, for example, with a vast number of equivalent configurations with different positions and velocities for each atom or molecule. A human, though, has low entropy – try to reconfigure us too much and things rapidly start to fall apart.

The crucial point is that there are more ways for any system of particles to have high entropy than low entropy, so things naturally tend towards high-entropy states. Where entropy is high, we lose any chance of knowing a system's precise physical configuration, because there are so many equivalent options. If we could gain all that information, time would still exist, in the sense that the system could still evolve. But time's arrow would disappear, because any "forwards" evolution would run equally plausibly "backwards" from the configuration in which we see it. "The increase of entropy is responsible for all of our impressions that the past is different from the future, including the impression that time flows," says Carroll – and our ignorance lies at its heart.

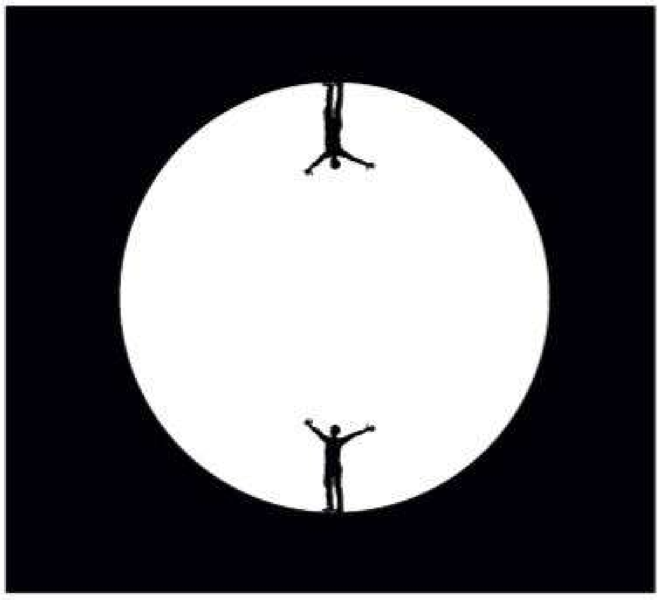
What is true in classical physics is doubly so in the quantum world, says Marcus Huber, at the Institute for Quantum Optics and Quantum Information in Vienna, Austria. Here, uncertainties that, in the classical world, we put down to a lack of knowledge seem to represent uncertainties intrinsic to reality, although that interpretation is itself up for debate (see "Why is quantum physics so strange?", page 44). "Here, the state is truly undetermined prior to a measurement, so the lack of knowledge – and rise of entropy – is even more fundamental," says Huber.

For some, arguments equating time's passage with rising entropy are passé, anyway. Lee Smolin at the Perimeter Institute for Theoretical Physics in Waterloo, Canada, for one, believes that the problem of time's arrow indicates a basic gap in our understanding. Others think the gradual revelation of classical certainties through quantum measurements is the true source of time's arrow.

Even if entropy is the answer, that just shifts the question. For entropy always to rise, the universe must have started with an astoundingly low amount. Why so? That's a question we have hardly begun to tackle.
Abigail Beall

05

Why are we good and evil?



THE evil that men do lives after them; the good is oft interred with their bones. So it will be with Dzhokhar Tsarnaev." So said Judge George O'Toole before sentencing Tsarnaev to death for his part in the 2013 Boston Marathon bombing. During the trial, it emerged that the killer was well liked by his teachers and friends, had been compassionate to people with disabilities and had apologised to victims and their families. But, said O'Toole, his goodness would always be overshadowed by his hateful act.

The human capacity for both good and evil, often within the same person, has long been recognised and puzzled over; O'Toole was quoting the Roman general Mark Antony in Shakespeare's *Julius Caesar*. What is it about us that endows us with such diametrically opposite propensities?

Evolutionary biology has an answer, and it doesn't reflect well on human nature. Acts of both good and evil are driven by altruism – and that is ultimately selfishness in disguise.

For a long time, altruism was a biological mystery. The prime directive of evolution is to pass on our genes to the next generation. Engaging in costly behaviours with no obvious survival pay-off seems to go against that grain. The polymath J. B. S. Haldane eventually twigged it: individuals mostly make sacrifices for close relatives, and hence help to usher copies of their own genes into the next generation. As Haldane put it: "I would lay down my life for two brothers or eight cousins." Acts of true selflessness exist, but these are explained as reciprocal altruism, where kindness to strangers (who may in fact be relatives) is banked for the future.

That's all good, but what about evil? Evildoers often see their acts as being for the greater good. This "pathological altruism" lies behind

"EVILDOERS OFTEN SEE THEIR ACTS AS BEING FOR THE GREATER GOOD" some of the worst atrocities in human history, including wars of aggression and genocide. The Boston Marathon bomber apparently thought that radical Islam was a good enough cause to maim and kill for.

We don’t come fitted with categories of people that are targets of our empathy or cruelty, says Steven Pinker at Harvard University, author of *The Better Angels of Our Nature: Why violence has declined*. “Whether we’re good or evil depends on what side of the sympathy boundary a particular individual is found,” he says. That largely depends on whether we see them as part of our “tribe” at any given point. If we don’t, we can treat others exploitatively or instrumentally, says Pinker. “We can keep slaves, we can engage in ethnic cleansing, we treat people like vermin.”

Even members of our in-group cannot count on our good intentions all the time. Our sense of justice is often indistinguishable from our sense of revenge, so we can be cruel when we think a person “deserves” it, says Pinker. A desire for dominance can lead us to disadvantage those we see as standing in our way, he says.

But humans also have the capacity for self-control and, perhaps uniquely, self-reflection, which has allowed us to suppress or moderate some of our baser evolutionary impulses. Innovations such as the rule of law, courts and the police go some away to reduce our power, or our incentive, to disadvantage others for personal gain. The continuity and stability this provides to our societies is one reason why, contrary to popular belief, evidence suggests evil is on the decline, says Pinker – and means our good need not always be interred with our bones. **Graham Lawton**

06

Why is the universe just right?

“WE LIVE in the best of all possible worlds.” So insists Professor Pangloss against all evidence to the contrary in the 1759 satire *Candide*, anyway. The writer Voltaire intended the character to lampoon certain theologically tinged scientific thinkers of the day, who insisted that things couldn’t be bettered because a beneficent deity would hardly have willed them otherwise.

Gods and their intelligent designs are less in the mainstream of scientific thought now, yet similar ideas about an optimal universe still trickle through cosmology. That is principally down to some mysterious numbers that determine its workings. Tot them all up in the standard models of particle physics and cosmology, and you end up with about 30 constants of nature – numbers like the strengths of the fundamental forces and the masses of elementary particles that our theories can’t explain, but are just “there”.

Change many of these constants, and nothing happens. “But with others, it’s drastic, not to say lethal,” says cosmologist Paul Davies at Arizona State University. Alter the relative strengths of gravity and electromagnetism just a little, say, and stars and galaxies can’t form. Flip the tiny difference in the proton and neutron’s masses to make the proton heavier, and you don’t even get stable atoms.

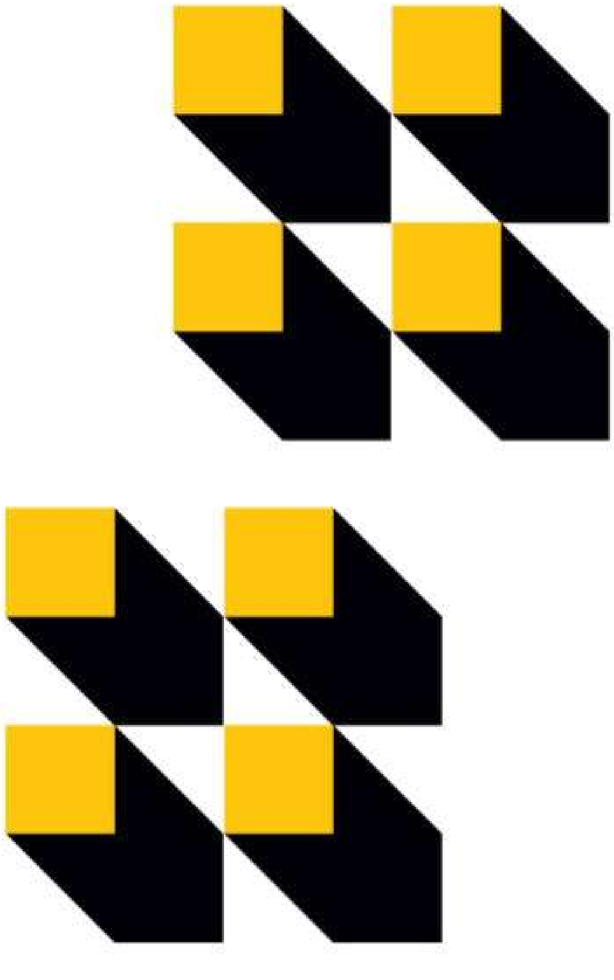
“Changing these numbers would probably preclude any life in the universe,” says Davies. It isn’t a big leap to say it looks like the knobs have been twiddled – as if the universe were somehow fine-tuned for our existence.

Stuff and nonsense, says Carlo Rovelli at Aix-Marseille University in France. “It is sad that even good scientists fall in this trap,” he says. “The universe is not ‘just right’, it is what it is.” For him, to say the cosmos is fine-tuned is a failure of imagination coming from no one really having the slightest idea how the universe would be if its vital parameters were any different. “It might be perhaps far more varied and interesting and with all sorts of strange, complex entities asking silly questions about how very, very just-right their universe is,” says Rovelli.

Back in 2008, astronomer Fred Adams at the University of Michigan did some knob-twiddling maths to back up this assertion. He showed, for example, that if the strong nuclear force were just a little stronger, stars could synthesise carbon more efficiently, creating a wider time window for life to evolve. On that reading, our “fine-tuned” cosmos is a botch job.

For many cosmologists today, to think the universe is in some way special is to make a mistake that has long plagued human thought: to think we are special. “Every scientific development in cosmology, starting from Copernicus onward, has shown us that we are not,” says Priya Natarajan at Yale University. To extend that thinking to the wider cosmos is, in part, a balance-of-probabilities hunch. “You have to decide if the origin of the universe is a natural, or a supernatural, event,” says Davies. “If it is a natural event, you wouldn’t expect it to happen just once.”

Such thinking is increasingly also an end point of many scientifically grounded hypotheses. One such is cosmic inflation, a flash of faster-than-light-speed expansion ›



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in the big bang's first instant that, for most cosmologists, is the best way to explain many features of the universe. Inflation, if it happened, would have been very difficult to stop, creating infinite universes budding off from one another faster than light speed, losing all causal connection with one another – and probably developing their own properties and parameters.

"If they do, just by chance, here and there, the numbers will come out just right," says Davies. In such a multiverse of many possible universes, our just-right universe is simply a matter of what is known as anthropic selection – questioning life will find itself in a universe suitable for questioning life. We're here because we're here, in other words.

For many cosmologists, the multiverse is as natural an answer as any. "I'm really quite comfortable with it," says Natarajan. Others, such as Rovelli, are less impressed. Some think the multiverse absolves physicists of all responsibility for trying to explain why things are as they are. Many criticise the lack, as yet, of any direct way to test the idea. Still, whether ours is the best of all possible worlds or just one of many, it seems reasonable to be grateful for what we have got. **Richard Webb**

07

Why are we conscious?

THE smell of coffee, the blue of the sky, the anticipation of seeing a loved one: it is impossible to imagine our lives without the vivid conscious experiences of our every waking moment. And yet they have vexed philosophers for centuries. "The nature of consciousness is extraordinarily difficult to define," says Eva Jablonka at Tel Aviv University in Israel.

It was once thought of as an immaterial force, a "ghost in the machine" separate from physical reality. Today, however, many neuroscientists argue that our felt experience is simply the product of our brain's inner workings. That makes the question of "why?" loom large. Many actions controlled by the brain occur unconsciously, beneath the level of our awareness. Why make exceptions?

Grasping this means thinking outside our own box, says Anil Seth at the University of Sussex, UK. "Human consciousness is not the only form of being conscious," he says. We tend to emphasise conscious experiences that make us think we are better and smarter than other animals, like our ability to recognise ourselves in a mirror, he says. "This is not very helpful."

The absolute fundamental of consciousness – having an actual experience of things – is something seemingly shared by many other organisms. "In my view, there are grades and varieties of awareness, and there is no principled dividing line about which – SHAZAM! – the light of consciousness is turned on," says Daniel Dennett at Tufts University in Massachusetts.

With a broader view of consciousness, we can look back along the tree of life to get an idea about its earliest glimmers. Jablonka, together with Simona Ginsburg at the Open University of Israel, has done this with a concept the pair call unlimited associative learning, a capacity to learn about and connect new stimuli,even when experienced at different times.

They found that the brain structures that could support this learning probably arose about 500 million years ago during the Cambrian period, a time of extraordinary evolutionary innovation – probably initially in primitive fish and arthropods such as trilobites and crabs, and around 250 million years later also in molluscs such as squid and octopus. By evolving this flexible capacity to learn, animals no longer needed to rely on reflexive, automatic behaviours in particular circumstances, and could devise better ways to evade predators, for instance. "This gives an enormous adaptive advantage," says Jablonka.

"Conscious experiences bring together a large amount of information in a unified way that emphasises the relevance for the survival prospects of the organism. And it all comes together in one unified scene that evolves from moment to moment. I think it is extremely useful for organisms," says Seth. Put this way, the "why?" of consciousness is just down to the vagaries of natural selection – just another random experiment that happened to confer a survival advantage (see "Why does evolution happen?", page 39).

And so it went on. Eventually, animals with more complicated brain structures evolved, giving rise to different and more complex forms of conscious experience, such as the ability to think about thinking. This may be a uniquely human trait, and it gives us a larger space of options for action and learning, says Dennett. "If you can think about your thinking, you can correct errors and devise new ways of doing things," he says. And, of course, ponder the nature of consciousness. **Alison George**

The pain of grief seems hard to explain if evolution is all about survival

JUSTIN PAGET/GETTY IMAGES

08

Why do we grieve?

“TIS better to have loved and lost than never to have loved at all,” wrote Alfred Tennyson. Try telling that to someone in the throes of grief. “It’s so awful and so debilitating. People don’t eat and they don’t sleep, and they don’t function,” says Randolph Nesse at Arizona State University. Aside from the overwhelming emotional pain and sadness, grief is bad for our physical health too: those who have been recently bereaved are more likely to have health problems and even die in the weeks and months following a loss.

Evolution is famously all about survival (see “Why does evolution happen?”, page 39). So if grief is so debilitating that it leaves us unable to cope with life, why did we evolve this trait? “It doesn’t make that much sense for people to be so dramatically impaired for so long,” says Nesse.

One popular explanation starts with childhood. When we are young and vulnerable, forming strong attachments and staying close to others is a smart survival move. The reactions of children separated from their mothers – an intense “protest” phase, followed by a withdrawn period known as “despair” – are also seen in grieving adults. More recently, neuroimaging studies have backed up this idea. When grieving people think about the deceased, a reward centre in the brain associated with social bonding lights up.

The protest phase of loss is also characterised in behaviours like grieving people needing to find or see the body, thinking they have seen the deceased alive and even believing in ghosts.

This “searching” behaviour for someone you know is dead might sound pointless, but it may have been different in our evolutionary past. “If you’re a hunter-gatherer and your 3-year-old disappears, you’re not just going to say, ‘Too bad’, you’re going to go looking for that 3-year-old for days and weeks and months,” says Nesse. “You’re not going to give up.”

More counter-intuitively, the withdrawn despair phase may also serve a purpose, by disconnecting us from the past and helping us to seek out a new future. “In evolutionary terms, there would be no value in somebody being celibate for the rest of their life,” says John Wilson at York St John University in the UK. From grieving our loss, we move on to cutting our losses.

Other factors give grief more survival value than might immediately be apparent. A mother whose child drowns after she lets it play too close to the surf, for example, will never make the same mistake again, says Nesse – and nor will any other parent who shares that grief. Grieving behaviours, such as crying, can help to elicit support from others at a time when we are alone, with clear survival benefits. Social bonding en masse might also explain outpourings of communal grief for public figures few people have ever met, such as Princess Diana, says Wilson.

In which case, we can turn the question around and ask why, if grief brings such survival benefits, don’t we all grieve equally? In a study of more than 1500 bereaved people, Nesse and his colleagues found that about a third of people don’t experience much grief.

He believes that is simply because evolution is a blunt instrument. “Natural selection shapes things that are jury-rigged at best. It’s not a fine-tuned system,” he says. In much the same way, just because some people experience chronic pain doesn’t mean that pain has no survival value.

Not everyone buys the idea of grief’s evolutionary benefits. Psychologist John Archer at the University of Central Lancashire, UK, has argued that it is an accidental “epiphenomenon”, resulting from bonding behaviours, that natural selection hasn’t found a way to ditch.

The ultimate test of this idea would be to invent a drug that did away with grief altogether. If it were an epiphenomenon, the drug would have no downsides. Nesse suspects that this would be about as wise as inventing a drug that did away with all pain: people who don’t experience pain are normally dead by the time they reach their 30s, he says. Would he take such a drug? The answer to that is a decided “no”. **Catherine de Lange**

09

Why is quantum theory so strange?

PARTICLES that also act like waves; the "spooky action at a distance" of entanglement; those dead-and-alive cats. Small wonder people often trot out physicist Richard Feynman's line that "nobody understands quantum mechanics". With quantum theory, we have developed an exceedingly successful description of how fundamental reality works. It also amounts to a full-frontal assault on our intuitions about how reality should work.

Or does it? "It only seems strange to us because our immediate everyday experience of the world is so very limited," says Sean Carroll at the California Institute of Technology. Intuitive-feeling classical physics is largely devoted to describing macroscopic objects – the things we see and feel directly in the world around us. "It should not be surprising that this breaks down when we push it into domains that we never experience directly," says Carroll.

There is a big difference between seeming strange and being strange, too. "If quantum mechanics is right, it can't truly be strange – it's how nature works," says Carroll. You can say something similar, after all, about other areas of physics, such as Albert Einstein's space-and-time-warping theories of relativity. Their effects only truly kick in at close to light speed, or in humongous gravitational fields of the sort we never experience, so their picture of the world seems alien to us.

For all that, there does seem to be something peculiarly alien about quantum theory. Take the way the mathematics of the theory allows us only to know the probability, on average, of what we will find when we measure the properties of a quantum object many times over, not tell us the outcome of any one measurement. This "measurement problem" raises the question of what quantum reality is doing before we measure it, and is the origin of Erwin Schrödinger's notorious thought experiment about cats that are both dead and alive until we determine which. Attempting to answer it leads physicists down all sorts of strange byways, from suggesting the existence of constantly branching parallel quantum worlds to suggesting an active role for consciousness in constructing reality.

Maybe we shouldn't worry so much about quantum theory's strangeness, says Nicolas Gisin at the University of Geneva in Switzerland. The theory works for what it is supposed to do, which is make predictions about the subatomic world. We don't know the extent to which it can or should apply to macroscopic objects. "I am certain that quantum theory is not the ultimate theory and there is no reason to believe it applies to the entire world," says Gisin. We should expect it to be strange, at least to the extent it is.

Others think a fundamental ambiguity is exposed by the measurement problem and other aspects of quantum weirdness such as entanglement, in which we see correlations that can't be explained by classical physics between measurements made on objects too far away from one another for any influence to pass between them. Is quantum theory a theory of the world as it exists objectively, or of how we interact with it?

"Part of the problem is that at present quantum mechanics is both," says Emily Adlam at the University of Western Ontario, Canada. Some bits of the mathematics seem to refer to objective physical processes, and others to our subjective inferences about them. "Whatever the underlying reality might be, it is mixed up with the inferential parts of the theory in such a complex way that it's hard to separate the two," says Adlam. In the words of physicist Edwin Thompson Jaynes, quantum theory is an "omelette that nobody has seen how to unscramble".

Even if we work out how to unscramble it, we may be left with a curate's egg. Broadly, Adlam agrees with Carroll that the problem lies with us. "Whatever that underlying reality turns out to be, it is almost certainly 'strange' relative to our classical experience," she says. **Daniel Cossins**

"THERE IS A BIG DIFFERENCE BETWEEN SEEMING STRANGE AND BEING STRANGE"

Why is there a cosmic speed limit?

TIME, various wags supposedly said, is nature's way of stopping everything happening at once. That might not be the most useful way of thinking about things, however, not least given our confusion about how time works (see "Why does time only move forwards?", page 39). Take a long, hard look at physics today and it isn't time that stops everything happening at once – it is light.

The idea that light always travels at the same speed, and that nothing can travel faster than that, is hard-baked into modern physics. It is still difficult to get your head around the mind-boggling consequences. Think of travelling in a spaceship with the beam of your headlights zinging off in front of you into the vacuum of space. A stationary observer outside your ship would see those photons travelling at light speed – 299,792,458 metres per second, for those taking notes. The crux is that so would you, no matter how fast your ship was travelling in the same direction.

According to Albert Einstein's theories of relativity, which he developed in the early years of the 20th century, space and time themselves warp to accommodate the otherwise insurmountable contradictions that arise from light's absolute speed.

His special theory of relativity gives a mathematical explanation for the cosmic speed cap: as objects with mass accelerate to higher speeds, they require more and more energy to keep them accelerating. To attain light speed, you need infinite energy – an impossibility. Light only gets a free pass as it has no mass, as in fact do other massless things, such as the ripples in space-time known as gravitational waves.

But why all that? One answer is that light speed – or let's just say, a cosmic speed limit – acts as a brake on the rate at which influences can propagate in the universe. If anything went faster, it would open the door to effects preceding causes. "If you can travel faster than light, you get all kinds of problems with causality," says Claudia de Rham at Imperial College London. The universe's past, present and future would conceivably occur in a jumbled mess all at once – and we wouldn't be here to wonder about it. In those terms, a cosmic speed limit might be one of those things that is "just so" in a universe with intelligent observers (see "Why is the universe just right?", page 41, and "Why is the universe intelligible?", page 48).

There remains the question of why that speed limit – why not twice as fast, say? Cosmologist João Magueijo, also at Imperial College, has spent years exploring the idea that the speed of light might have started off much higher, perhaps infinite, at the big bang and slowed down since. This would explain certain puzzling features of the universe today such as its strange uniformity. "This is actually a very minor tweak to relativity," he says.

A speed of light that evolves over time wouldn't itself be that dramatic, says de Rham, but she adds that current observations give no reason to believe it does. There would still need to be some other parameter behind the scenes that sets how the speed of light changes, she says – so such considerations don't help much with the "why?".

For his part, Magueijo suspects that the speed of light is bound up with very deep matters of physics that we don't fully understand yet, relating to the nature of space and time themselves and whether they emerge from some deeper layer of reality. Get a glimpse of what is pulling the strings, and the cosmic speed limit isn't the only thing we might see in a whole new light. **Joshua Howgego.**

ANDRIY ONUFRIYENKO/GETTY IMAGES

Light's finite speed is what separates causes from effects

11

Why are we irrational?

How does banning concealed handguns influence crime rates in US cities?

	Crime rate increased	Crime rate decreased
Gun control	75	223
No gun control	21	107

TAKE a look at the data to the right, showing crime rates in US cities according to whether or not they ban concealed handguns. Based on these numbers, would you conclude that gun control reduces crime? Take as much time as you want.

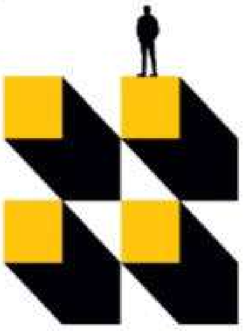
If you answered no, give yourself a pat on the back. Most people answer yes, dazzled by the large number of cities with gun control and decreasing crime. But what matters is the proportion of cities with falling crime. That’s 75 per cent for cities with gun control and 84 per cent for those without. The rational conclusion is that gun control increases crime, or at least doesn’t decrease it.

Before you punch the air or a passer-by, the data is fake. But faced with it, supporters of gun control are more likely to jump to the wrong conclusion. Opponents of gun control scrutinise the data more cautiously and more often spot the real pattern.

The test is designed to winkle out a pervasive and intractable source of human irrationality, the myside bias. It expresses the tribal thinking that evolution has gifted us (see “Why are we good and evil?”, page 40): a tendency to seek and accept evidence that supports what we already believe. “You direct your reasoning to end up with a conclusion that is already a sacred belief or a shibboleth in your side, your team, your coalition, your party, your posse,” says Steven Pinker at Harvard University, author of *Rationality: What it is, why it seems scarce, why it matters*.

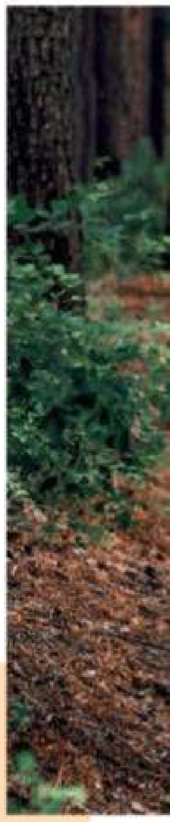
On an individual level, such “motivated reasoning” is generally fairly harmless, but once promoted to group level, it can unleash chaos. The obvious example is climate change, where positions are determined almost completely by politics and denial is impervious to scientific facts.

Yet there is no reason to conclude that humans are fundamentally irrational. Our brains evolved to deal with proximate dangers to our own survival and that of our kith and kin. In performing life tasks such as holding down a job and putting food on the table, most of us act rationally for the majority of the time. A gradual, distant danger such as climate change, however, pertains to the world beyond immediate experience. This contains the deep past and far future, the microscopic and cosmic, distant peoples and places, the goings-on in palaces and corridors of power. Here, we generally have no way of knowing the answers but still desire them.



We have developed many tools to analyse such situations rationally: logic, probability, Bayesian reasoning, game theory, correlation versus causation and so on. But these don’t come naturally to us. We often fall back on conjecture, in the form of exciting, morally charged stories, a mode of thinking that furnishes the world with paranormal beliefs, fake news and conspiracy theories.

Are they now gaining the upper hand? There is little evidence behind the widespread perception that irrationality is on the march, says Pinker – just as there is little evidence that the tools of enlightened reasoning have seriously reduced the global prevalence of codswallop. The problem is, we look at the available data and see what we want to see. **Graham Lawton**



WESTEND61/GETTY IMAGES

> “THERE IS LITTLE EVIDENCE THAT IRRATIONALITY IS ON THE MARCH”

12

Why haven't we heard from aliens?

IN 1960, astronomer Frank Drake began an experiment. With a radio telescope, he studied two nearby sun-like stars, hoping to find signals that could only have been generated by life on planets orbiting these stars. He came up blank. In the six decades since Drake started the search for extra-terrestrial intelligence (SETI), astronomers have kept listening, carefully and systematically. Still, we have heard nothing.

One possibility is that there simply are no aliens out there – that we truly are alone. But this seems unlikely, given the vastness of the cosmos, with hundreds of billions of galaxies containing hundreds of billions of stars, most of which have at least one planet orbiting them, at least according to our burgeoning knowledge of exoplanetary systems in our own galactic neighbourhood.

Jill Tarter, co-founder of the SETI Institute in California, says we haven't listened for long enough or looked hard enough to make any such sweeping statements yet. Astronomers have studied all kinds of electromagnetic radiation – light, radio waves, gamma rays – looking for signals. Such a search has to cover all directions and distances in space, plus the different ways a signal might manifest itself, such as shifts in polarisation, frequency, modulation and intensity. Tarter sees these parameters as a multi-dimensional ocean. "When SETI turned 50, we had explored one glass of water from that ocean. By the time it turned 60 it was more like a small hot tub," she says. "It's getting better and faster all the time, but there's a lot more to explore."

According to Beth Biller, an astronomer at the University of Edinburgh, UK, searching through time is the biggest challenge. Humans have only lived on Earth for the blink of an eye compared with the age of the universe, and we have only been broadcasting our presence with things like radio waves for just over a century.

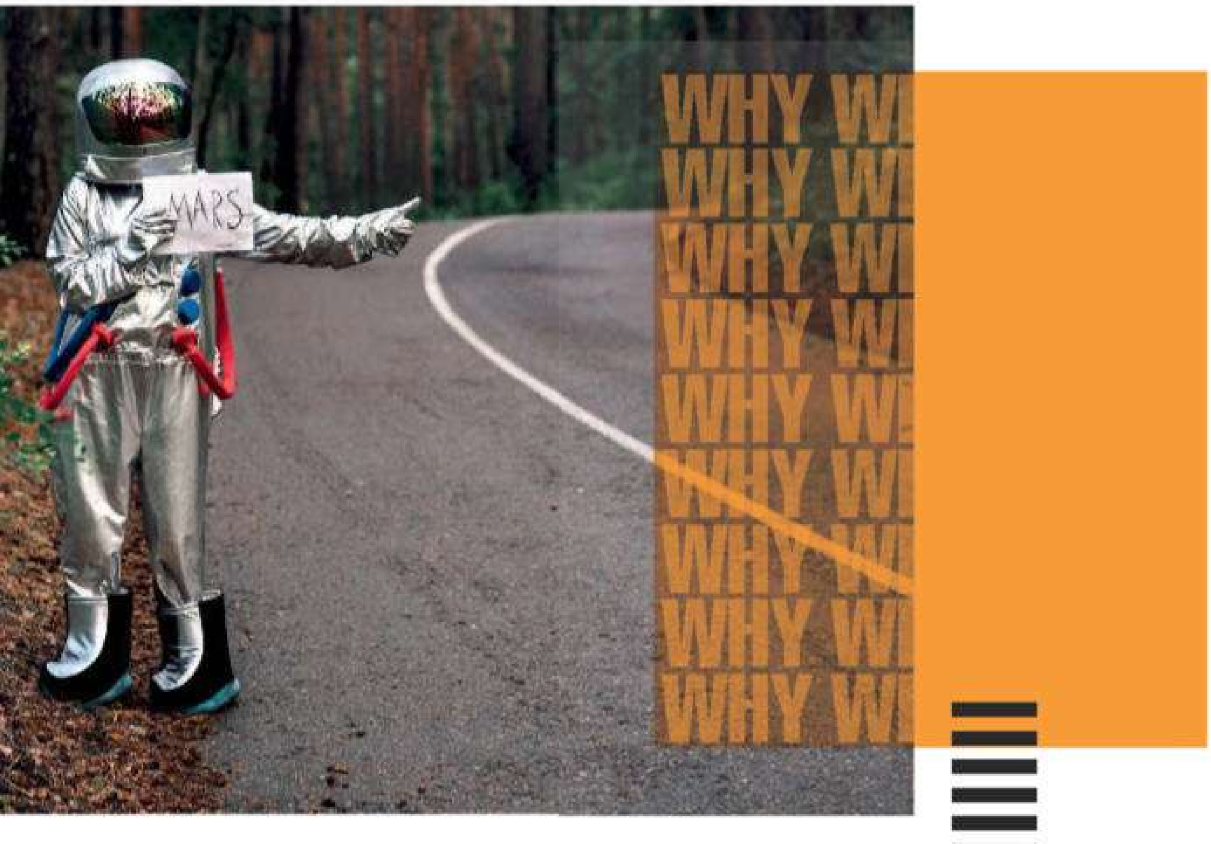
"The civilisation that you want to contact has to exist at the same time as your own civilisation," says Biller, which given light's finite speed of travel, could be thousands, millions or billions of years in the past once their signals reach us, depending on how far away from Earth you are looking. "When you're talking about finding aliens, you just have to get a lot of timings correct," she says. Electromagnetic waves from other worlds will radiate in all directions, so the further away we are, the fainter any signal will be. Even the closest neighbouring star system to Earth, Proxima Centauri, is more than 4 light years away, putting a big delay on any conversation.

Even if a transmitting alien civilisation were close enough, we might not see it. Around 70 per cent of exoplanets have been found using the transit method, which involves observing the light from stars periodically dimming when planets pass in front of them. A study published in June 2021 by Lisa Kaltenegger, an astronomer at Cornell University in New York, and her colleagues turned this logic around to ask how likely aliens would be to see us using this method.

They identified just over 2000 systems within about 300 light years of Earth that might see our planet in this way at some point between 5000 years ago and 5000 years from now. Within the list, there are seven stars with planets in the habitable "Goldilocks zone", where it is the right temperature for liquid water on the surface, of which four are close enough to have already received radio waves. Most of them lie in a heavily populated area of space so far unexplored by exoplanet surveys, at least until NASA's Transiting Exoplanet Survey Satellite (TESS) started operating in April 2021. "And yes, I gave them the star list to search for planets," says Kaltenegger.

Even a continued no-show might not tell us much. If alien life forms exist, it might be that intelligence or technology are rare. Perhaps technological civilisations are simply too combustible, liable to destroy themselves before they can make their presence unambiguously known. Perhaps they do know about us – but have decided to leave us alone.

Or perhaps we are simply looking for the wrong thing, our focus on electromagnetic signals reflecting the state of our current technology. Why not gravitational signals, say – or something else entirely? "We may have to discover new physics before we get it right," says Tarter. **Abigail Beall**



Alien life hasn't made its presence obvious so far

Why is the universe intelligible?

13

ONE way to look at why the universe is intelligible is to ask where we would be if it weren't. We certainly wouldn't be asking the question; we probably wouldn't be aware of it being a sensible question to ask. "What we call 'intelligibility' is a cognitive relation we happen to have with the universe," says Carlo Rovelli at Aix-Marseille University in France. "This isn't a question about the universe, it is a question about ourselves."

We are natural pattern-seekers, this argument goes, because seeking and understanding patterns in the world around us has survival value. "Our species, in its evolution, found it advantageous to be curious, so we are curious," says Rovelli. Applying that curiosity to the universe allows us to see patterns there. Its intelligibility is a product of biological evolution.

For others, that is only half the story. "The remarkable thing is that the world is not arbitrary or absurd," says Paul Davies at Arizona State University. "There's a scheme of things that we can uncover using science and mathematics – that's already one enormous thing." It seems a fair bet that an inverse-square law of gravity, say, exists in our universe without us being there to say so. Why?

One answer might be some form of anthropic selection principle (see "Why is the universe just right?", page 41): only a regulated, predictable universe is likely to provide the conditions for questioning observers to arise. Then again, some specific aspects of our universe aid our comprehension of it, but don't seem to be particularly crucial for our existence. Take the fact that our universe is expanding and evolving from a big bang (see "Why is there something rather than nothing?", page 37). That, plus light's finite speed, means we can peer out to different distances and get a sense of what the cosmos looked like in different eras right back almost to the beginning.

Granted, that leads us to some pretty dark places. To square what we see with our models, we end up proposing that 95 per cent of the stuff in the universe comes in two entirely mysterious forms, dark matter and dark energy. Aren't they a problem for claims of an intelligible universe?

Not really, says Priya Natarajan at Yale University. We might not know what they are, but observation demands something like them exist. "I would call them placeholders," says Natarajan. "They are reminders science is inherently provisional."

For her, all of this leads us to a glorious paradox. "Here we are with a gelatinous thing the size of a cantaloupe inside our head, and yet we have figured all this out," she says. That makes us very significant – and yet these investigations have revealed our sheer insignificance in a vast, apparently lonely cosmos (see "Why do we exist?", page 38).

Davies thinks that leads in a profound direction. "The universe is able not only to be self-aware, but self-comprehending: a microcosm of the universe is able to comprehend the whole," he says. He thinks a pathway from matter to the existence of mind and comprehension is built into the structure of the universe in some fundamental way – a speculation he admits puts him out of step with most of his colleagues. "It's the closest I will get to any sort of religion," he says.

Then again, there might be limits to our comprehension. One big question mark comes from quantum theory: not least from the way it seems to blur the strict separation between subject and object, the observer and the observed, that has allowed us to make progress in understanding the wider world (see "Why is quantum theory so strange?", page 44). "We don't actually have a framework to think about science without these dichotomies," says Natarajan.

Perhaps the enormous progress we have made in the past 300 years or so in understanding the universe using cast-iron physical laws is an aberration that results from selecting a subset of problems amenable to such an approach. The quantum realm, our own minds and complex systems generally might be far tougher nuts. "We could envisage in another 500 years people thinking: 'That was a quaint, old-fashioned way of investigating the world, writing down your equations and hoping to make discoveries of Earth-shattering importance'," says Davies.

Already there are signs that the only way to tackle such problems might be using the data-crunching power of artificial intelligence to uncover patterns of correlation. Does this mean that, in future, the universe will be intelligible, but only by machines, not directly by humans? Davies thinks it is a possibility. "I hope that's not the case, I really do," he says. "But I can't give you a proof." **Richard Webb** ▮

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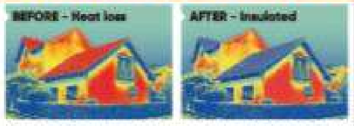

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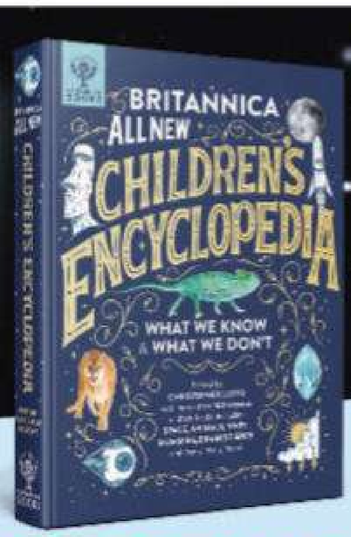
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Telephone 020 7831 0575 Email: c.loughlin-chow@gresham.ac.uk

The closing date: 9:30 am **Monday 24 January 2022.** Interviews will be in London on **Thursday 3 March 2022.**

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The science of cooking

In praise of oysters

The humble oyster inspires passion in many and fear in others. **Sam Wong** looks at a scientifically sound way to eat them

Sam Wong is social media editor and self-appointed chief gourmand at *New Scientist*. Follow him @samwong1

What you need

Oysters
Butter
Garlic
Hot sauce
Lemon juice
Champagne? Oh, go on then

I LOVE raw oysters, so hoped to write a column saying there is no need to worry about food poisoning. When I looked into it, though, I found cause for concern. But there are safe ways to enjoy delicious oysters.

Folklore has it that oysters can be eaten in any month with an "r" in it – in other words, avoiding the summer months, when they spawn. This discernment may date back to ancient times. By measuring parasitic snails in oyster shells, a study of a 4300-year-old human habitation in Georgia, US, found that ancient people mostly harvested oysters in the autumn, winter and spring.

During the spawning season, oysters convert their resources into sperm or eggs, which renders them less palatable. People may also have avoided taking oysters in summer to allow populations to recover.

Nowadays, farmed oysters are available and good to eat all year round and are among the most sustainable seafoods. Since the 1980s, many farmed oysters have been triploid: they have three sets of chromosomes and are therefore infertile. These oysters grow faster than natural oysters and remain firm and plump in the summer.

As filter-feeders, oysters can pick up pathogens lurking in the water. To reduce this risk, they are usually kept in clean water for 42 hours after harvesting in the UK, a process called depuration.

Sadly, this isn't completely effective – particularly with respect to norovirus, one of the most common causes of gastroenteritis. A 2017 report found that between 100 and 1000 copies of the norovirus genome may remain in each gram of oyster tissue after depuration. Just 10 copies are thought to constitute an infectious dose.

SHUTTERSTOCK/AQUARIUS STUDIO

In the UK, about 13,000 people a year experience illness after eating seafood, usually raw oysters. Given that more than 13 million oyster meals are served each year, you might consider this a low risk. But recent headlines about raw sewage discharged around British coasts may make you think twice.

Fortunately, cooked oysters are delicious too. The simplest method is to oven cook oysters at 220°C for 10 minutes. Heat will cause the shell to open, so place them on a wire rack or a bed of salt to stabilise them, so the juice doesn't leak out. Once cool enough to handle, use a knife to gently separate the oyster from the shell. To serve, spoon on some melted butter with garlic, hot sauce and lemon juice.

Champagne is another traditional accompaniment to oysters, and a study identified a reason behind this pairing. Oysters and champagne contain compounds that activate umami taste receptors: glutamate from dead yeast cells in champagne and nucleotides in the oyster muscles. Combined, they create a stronger perception of umami than either does on its own. ▮

The science of cooking appears every four weeks

Next week

Stargazing at home

These articles are posted each week at newscientist.com/maker

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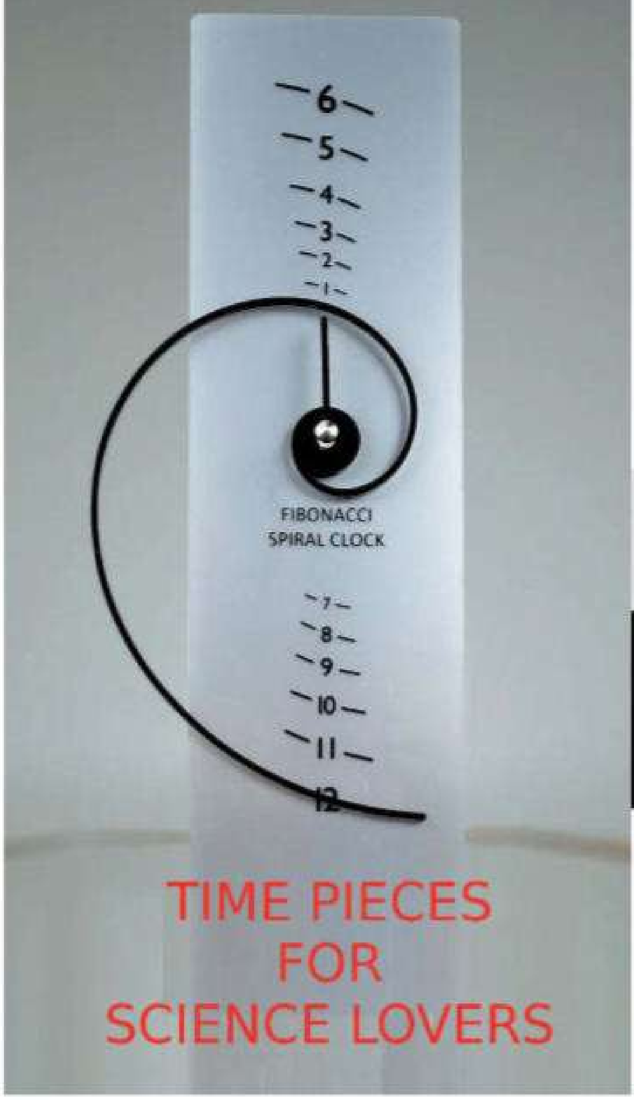

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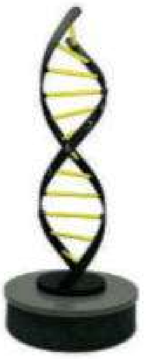

Conics

Newton
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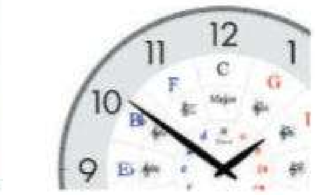
Circle of 5ths



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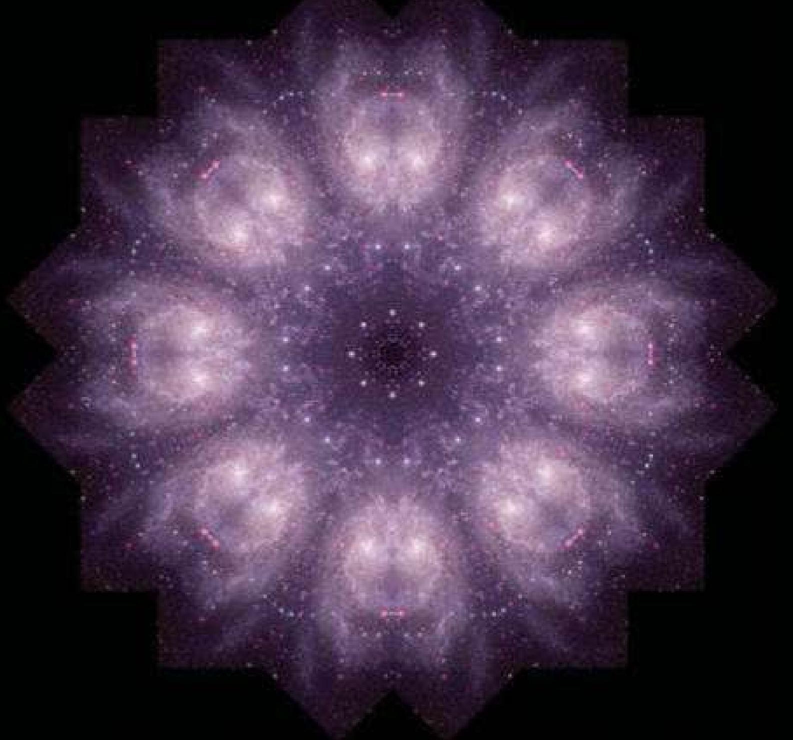

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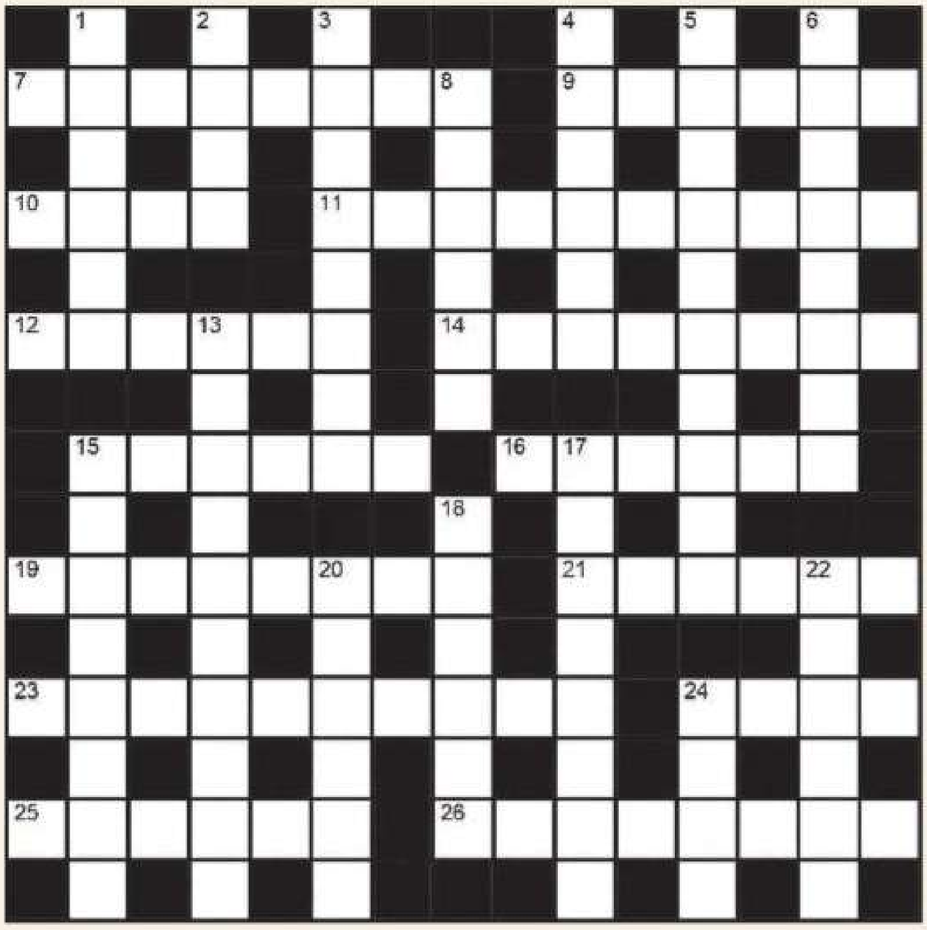
Quick crossword #96 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

7 Pt (8)

9 Womb (6)

10 1982 sci-fi film by Steven Lisberger (4)

11 Part of the digestive tract (10)

12 Nocturnal lemur of Madagascar (3-3)

14 N (8)

15 Swelling in the neck (6)

16 Configured assembly of open-source software components (6)

19 Devices (8)

21 Mechanical model of the solar system (6)

23 Steel, for example, formed into thin panels (5,5)

24 Vapour (4)

25 Lightning ___, atmospheric electrical discharge (6)

26 Technology deployed on a molecular scale (8)

DOWN

1 Howard ___, Australian pharmacologist who developed penicillin (6)

2 British sub-machine gun (4)

3 Technician in the field of machines, materials, structures and systems (8)

4 Disappearance of Earth's star behind the horizon (6)

5 Type of rotorcraft (10)

6 Component of the psyche in psychoanalytical theory (8)

8 Distinct organism resulting from alterations to a genome (6)

13 Study of numbers (10)

15 Crystalline form of carbon (8)

17 Mechanical respirator (4,4)

18 Compound, $C_8H_5NO_2$, also known as tribulin (6)

20 Integer, perhaps (6)

22 In surgery, to remove all or part of an internal organ (6)

24 Winged insect, usually nocturnal (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #128

1 The coxa and trochanter are found in which part of an arthropod?

2 Which of these periods in the lunar geological timescale came first: the Imbrian, the Copernican or the Eratosthenian?

3 For how many years did the Human Genome Project run?

4 The term "monotreme" refers to an area of some animals' anatomy. What area is it?

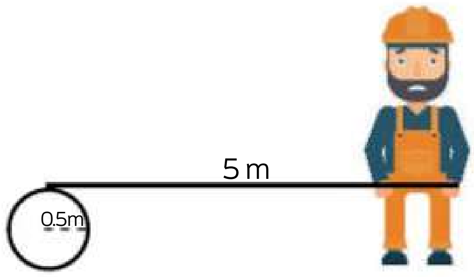
5 Monel alloys are primarily made up of nickel and which other element?

Answers on page 55

Puzzle

set by Howard Williams

#140 Drum roll



SHUTTERSTOCK/VISUAL GENERATION

Aiming to mix the contents of a rusty drum without getting dirty, Mr Bodger has an idea. The drum is lying on its side, so he wants to place one end of an old plank, which is 5 metres long, on the side of the drum, then walk towards the drum while holding onto the plank. In this way, he will use the plank to roll the drum (without any slipping with respect to both the ground and the plank) to mix its contents. He will stop walking when he reaches the drum.

In fact, Mr Bodger has many drums that require similar treatment, and he is a lazy sort of fellow, so he consults his friend Mr Hasty about how far he will need to walk to mix each drum. After giving the problem his undivided attention for 10 seconds, Mr Hasty assures him that as the plank is 5 metres long, and the radius of each drum is 0.5 metres, then the maximum distance he will need to walk each time is 4.5 metres.

This is incorrect, but by how much is Mr Hasty out?

Solution next week

THANUMPORN THONGKONGKAEW/ALAMY

Can you really tune in to the natural frequency of the solar system?

This week's new questions

Solar vibe **My yoga teacher is hosting a gong bath where the gong is supposedly tuned to the frequency of the solar system. Does the solar system have a frequency? If so, is it possible to tune a gong to it?** ***Natasha Aidinyantz****, Watford, Hertfordshire, UK*

Dead and gone **There are estimated to be around 160 million birds in the UK with a lifespan of two to five years. Why do I never see a dead one?** ***Robert Morley****, London, UK*

Purrfectly formed

Cats were domesticated in ancient Egypt, yet unlike other domesticated animals, don't seem to have evolved significantly since. Why?

Emma Smith
Bristol, UK

I have come to the conclusion that humans are at the whim of three things in life: the weather, hormones and cats. Ask any cat owner and you will discover that they have to do exactly as the animal bids, whether that means sitting uncomfortably so as not to disturb the cat sleeping on their knee, or holding open a door while it twitches its "tail of indecision" before running the other way.

I therefore suggest that humans have subtly evolved to meet the needs of cats rather than the other way round.

James Thompson
Canterbury, Kent, UK

It could be argued that the domesticated European house cat has reached the top of the evolutionary ladder, with all the benefits of a 21st-century Western lifestyle and none of the drawbacks. It is worth thinking about this next time Tiddles jumps into your warm spot as you head off to work on a winter morning!

> "A special human-cat relationship was established that mutually benefited the first farmers and the cats themselves"

Eva-Maria Geigl
Jacques Monod Institute,
Paris, France

When travelling in Egypt, visiting tombs from pharaonic times and looking at 4000-year-old frescos and statues featuring cats, one gets the impression that they were essential to the afterlife of kings, nobles, craftsmen and scribes. There are so many depictions of them throughout that period.

There are the ferocious tomcats cutting off the head of a serpent demon, cats under the chairs of noble people, statues of cat-like goddesses and many cat mummies. These cats resemble present-day barn, village and house cats. Does this mean that cats were domesticated in Egypt but haven't changed since?

As is true for the history of all domestic animals, the reality is much more complex. First of all, cats were probably domesticated in the Middle East at the dawn of agriculture thousands of years before they were introduced to Egyptian households.

In the Middle East, the local wildcats must have been attracted by the rodents prowling around granaries in the settlements of early farmers. A special human-cat relationship was established that mutually benefited both partners: the cats must have been happy to feast on these rodents, while the farmers must have been happy to get rid of the pests.

Was there a need to breed and change them? No, since the cats behaved exactly as these farmers wished: they killed rodent pests, and there was no need to feed or take care of them. They weren't dangerous, but simply a gift to farmers.

This didn't change for 10,000 years or so until the British created fancy breeds towards the end of the 19th century, and so there are all kinds of pure-bred cats today. Yet they are still much more like their ancestors compared with dogs, many of which are radically different from wolves, their wild forebears. This is because dogs experienced a long history of breeding for specific tasks.

Nevertheless, there are some differences between wild and domestic cats: wild cats are solitary and pure carnivores, while house cats tolerate (and sometimes even like) other cats and humans. Some even like milk and cake. Through research at our lab on the DNA of ancient cats, we may even find other changes.

Chris Kendall
Leicester, UK

Cats are phenomenally lazy. As such, they haven't evolved significantly since domestication because it is too much like hard work and it interrupts nap time.

Right on time

I've been sent an appointment for 11.17am. Why do I perceive it as being more demanding of punctuality than 11.15 or 11.20, say?

Hillary Shaw
Newport, Shropshire, UK

Because we think in fives or tens, 11.15 can feel like anywhere from 11.13 to 11.17, whereas 11.17 demands arrival between at least 11.16.30 and 11.17.59.

Old analogue watches and clocks encourage this "round fives" thinking with their 1 to 12 dials. Older timepieces such as chiming church clocks encouraged punctuality merely to the nearest hour. Our digitised society may be getting more demanding in terms of punctuality.

Peter Basford
Potters Bar, Hertfordshire, UK

A traditional clock face is marked at the quarter hours and usually

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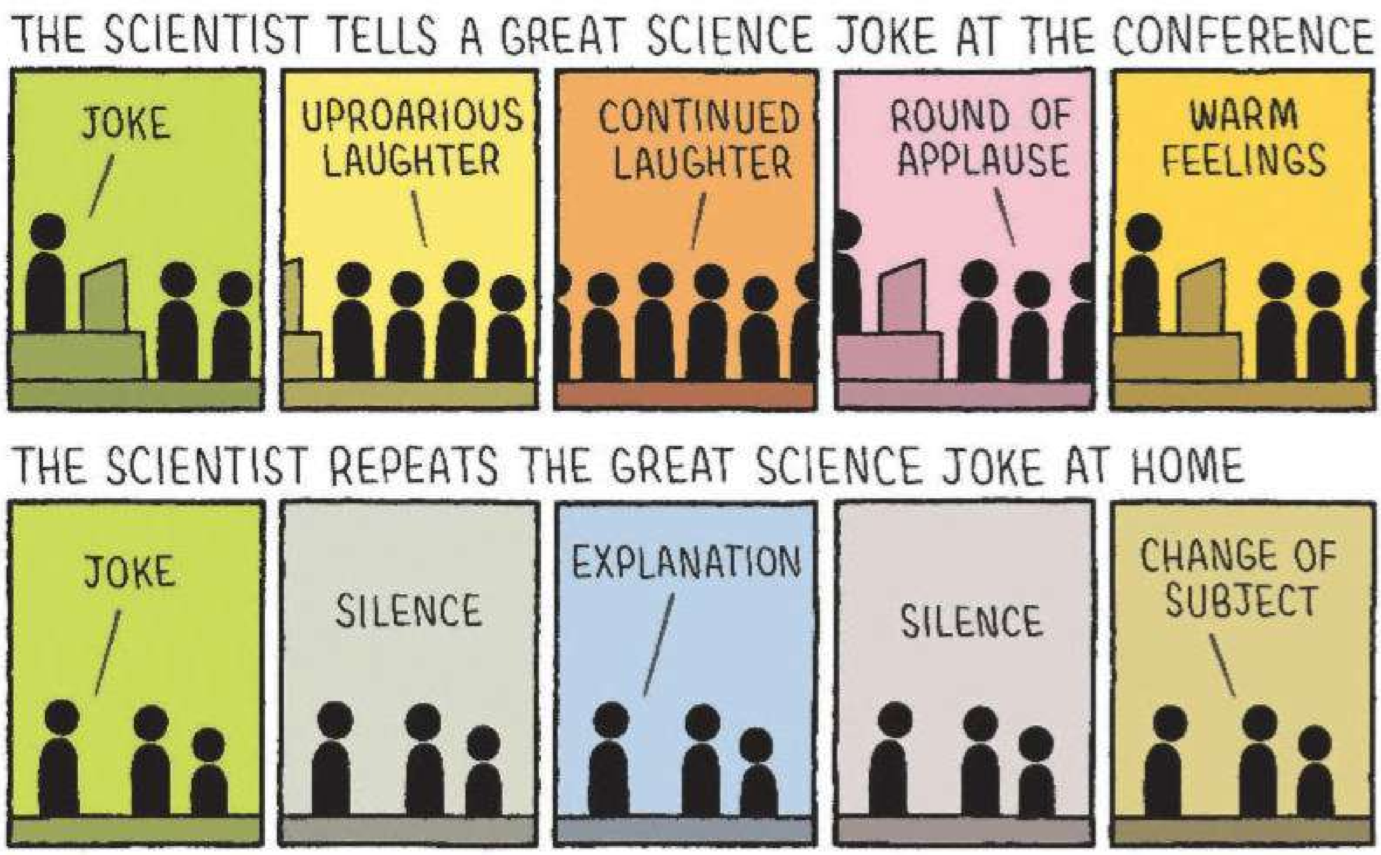

> **"Chiming church clocks encouraged punctuality merely to the nearest hour. Digital clocks may be more demanding"**

at each 5-minute interval too. An arrangement at those times can therefore be seen as chosen for convenience when reading the clock rather than being precisely synchronised to an event.

The ambiguity of a time like 11.15 can be resolved by context. No one cares if I arrive at the coffee shop to meet you at 11.18, even though we arranged 11.15, but we all understand that 11.15 on a train timetable means exactly that. Setting an appointment at 11.17 is a clear demand for punctuality.

Andrew Vaughan
Horsham, West Sussex, UK
We are accustomed to approximating time: 10 past, quarter to, etc. Therefore, when faced with an appointment at an unusual time, our brains are triggered to pay extra attention and presumably turn up on time.

I once had a colleague who set meetings for uncommon times. His strategy backfired as we rebelled against the implication that we couldn't turn up at conventional times. My compatriots and I always showed up fashionably late.

Dying to be green

Indestructible coffins aside, what is the most environmentally friendly way to deal with our bodies after death? Is burial better than cremation? (continued)

Peter Calver
Stansted, Essex, UK
The most environmentally friendly way to deal with a dead body is to eat it.

James Leedam
Monmouth, UK
Local natural burial, in its purest form, is the most eco-friendly way to deal with our remains. This is a simple burial without toxic embalming, within a few days of death, in a locally handmade woollen shroud or a coffin made from wicker or sustainably sourced timber. The grave should make minimal impact on the landscape, in a location where the products of decomposition won't pollute groundwater. Any memorial, crafted from locally sourced materials, should be remote from the grave. This allows the land to remain as a hay meadow, pasture or woodland, or as a wildlife conservation area.

In response to the Dutch study mentioned in a previous reply to this question, comparing the environmental impact of cremation and burial: this didn't consider natural burial. It also added the carbon cost of cemetery maintenance and imported granite memorial stones to burials. These assumptions, which led to the conclusion that cremation had a lower impact, aren't correct in the UK. Keeping things simple, local, modest and natural will make the biggest difference. ▮

Answers

Quick quiz #128
Answers

1 The leg

2 The Imbrian

3 13 (from 1990 to 2003)

4 The cloaca, the single orifice for the digestive, reproductive and urinary tracts

5 Copper

Cryptic crossword #70 *Answers*

ACROSS 1 Annie, **4** Bodices, **8** Eschewing, **9** Oar, **10** Barnacle, **11** Jump, **13** Cannon, **15** Agatha, **18** Save, **19** Air tubes, **22** Mic, **23** Astronomy, **24** Cistern, **25** Humid

DOWN 1 Alembic, **2** Nicer, **3** Elevator, **4** Bridle, **5** Doge, **6** Croquet, **7** Strep, **12** Egg tooth, **14** Novices, **16** Assayed, **17** Piston, **18** Sumac, **20** Broom, **21** Fare

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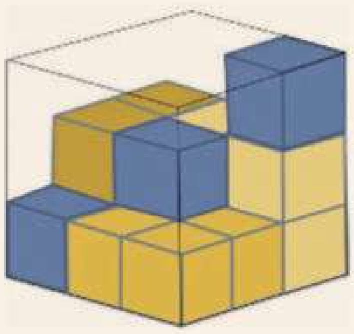
#139 BLOXO cubes
Solution

The six yellow four-packs and three single blue blocks will all fit. The blues are placed along the diagonal of the 3x3 box.



The back pages Feedback *at COP26*

Occasionally, Feedback is allowed out of the office stationery cupboard. Just very occasionally, we do so to attend international summits where the fate of humanity hangs in the balance. And so we found ourselves bound for COP26 in Glasgow, armed with 65 years of accumulated wisdom – institutional, but not quite yet institutionalised.

Eliminating elephants

If we kissed the ground on arrival, it was only to commune with a floor poster at Glasgow Central station proclaiming that Scotland's railways had reduced their carbon footprint by 5000 elephants, and inviting us to join their "journey to net zero".

We can only endorse the suggestion from Alex Bowman, a Glasgow native who also spotted the poster, that we need a standard prototype elephant if such reductions are to be verified. Having net-zero elephants strikes us as a more problematic concept, although not outside the envelope of where we might be heading if we can't bend the climate curve.

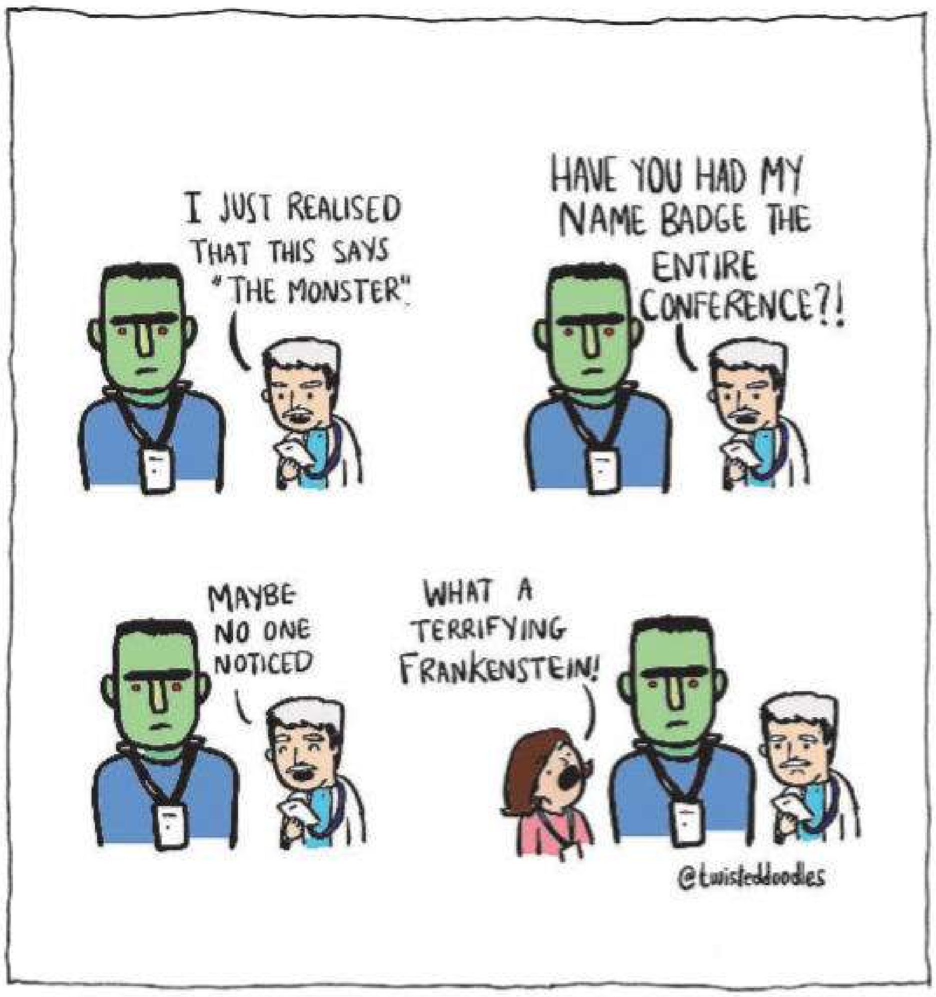
Subtle diplomacy

"Do you have a copy of the text?" a delegate hissed at us. We didn't: we only wandered into this room, its desks furnished with microphones arranged in a large square pointing inwards, in search of a cup of tea.

It turned out to be video-linked to negotiations next door that were hammering out a communiqué on long-term climate finance. In fact, no one had a copy of the text, which made things a little hard to follow. The negotiation facilitator, who called out nations by number to speak their turns, had a world-weary air. "I feel like a bingo caller," he said at one stage.

A particular sticking point was a clause saying the conference "notes" the efforts of high-income countries towards mobilising $100 billion a year of long-term climate finance. Make it "expresses concern at the lack of", suggested India. Try "welcomes", countered Australia. "I really don't want to be wasting time on this," supplied Switzerland, in an admirably neutral if undiplomatic vein. This is how the future is decided.

Twisteddoodles *for New Scientist*


I JUST REALISED THAT THIS SAYS "THE MONSTER"
HAVE YOU HAD MY NAME BADGE THE ENTIRE CONFERENCE?!
MAYBE NO ONE NOTICED
WHAT A TERRIFYING FRANKENSTEIN!
@twisteddoodles

Got a story for Feedback?

Send it to feedback@newscientist.com or New Scientist, Northcliffe House, 2 Derry Street, London W8 5TT

Consideration of items sent in the post will be delayed

Gaiety of nations

Considerably more fun was the exhibition space, where nations and organisations set up pavilions to outcompete each other in green messaging. Feedback's highlights included the International Bamboo and Rattan Organisation's bamboo bicycle, delightfully lightweight and a joy to ride, although it remains to be seen how it would fare in an altercation with a panda... car.

The life-size polar bear models in the pavilion from the Pacific island nation Tuvalu were a reliable draw for selfie-seekers, at first sight an implausible juxtaposition, then a poignant statement connecting those with most to lose in a melting world. The corporate-sponsored Climate Pledge Theatre attracted much ribaldry on social media, as a kind of meta-commentary on the lack of climate action for which the COP process has become famed.

Alcohol flowed most freely in the Scandinavian pavilions. Presumably for lack of anything particularly ecological to say, Qatar ignored climate change entirely and focused on eye-bulgingly strong coffee and scale models of the stadia for the 2022 football world cup.

On the final Thursday afternoon, with time running out to seal a deal, UN Secretary General António Guterres warned in the main hall that the world was on a track to catastrophic warming. In Pakistan's pavilion, people were watching the T20 world cup semi-final against Australia. There is important stuff, and then there is cricket.

Buzzword RINGO

BINGO, ENGO, RINGO, TUNGO, YOUNGO, IPO, LGMA, WGC and Farmers: not Santa's reindeer or an expanded and updated list of the seven dwarfs, but the nine "constituencies" with observer status at climate negotiations.

These are roiling seas of acronyms and initialisms. "BINGO" is an exalted nested example, the grouping of "business and industry NGOS". "Farmers" are farmers, and we leave you to work out the rest.

Some abbreviations have become untethered from meaning, floating adrift of words that might reasonably constitute them. CMA is the shorthand for signatories of the Paris climate accord; quite how is also left as an exercise for the reader. COP = conference of the parties, but you knew that one.

Omnibus Potemkin

Outside the perimeter fence, protesters marched, coalesced and unfurled, while Glasgow, the Gaelic "dear green place", gave of its best. More than its best, perhaps, as fleets of electric buses ferried delegates to and from the city centre, travelling free thanks to a universally valid public transport smartcard. Perish the thought that any such radical policies should be adopted in our journey towards net zero.

Fair COP

"HURRY UP PLEASE IT'S TIME", read an artwork in neon lights opposite COP26's one and only bar, an urgent message to delegates both to drink up and to face up to their responsibility to change the world. When a deal was finally struck deep into overtime, exhausted delegates negotiated the world's pavilions in an advanced state of deconstruction. Insert metaphor here.

It wasn't enough; it never could be. COP26 was messy and human, a chaotic, uneasy amalgam of science, diplomacy and activism. And it supplied our best hope. ▮

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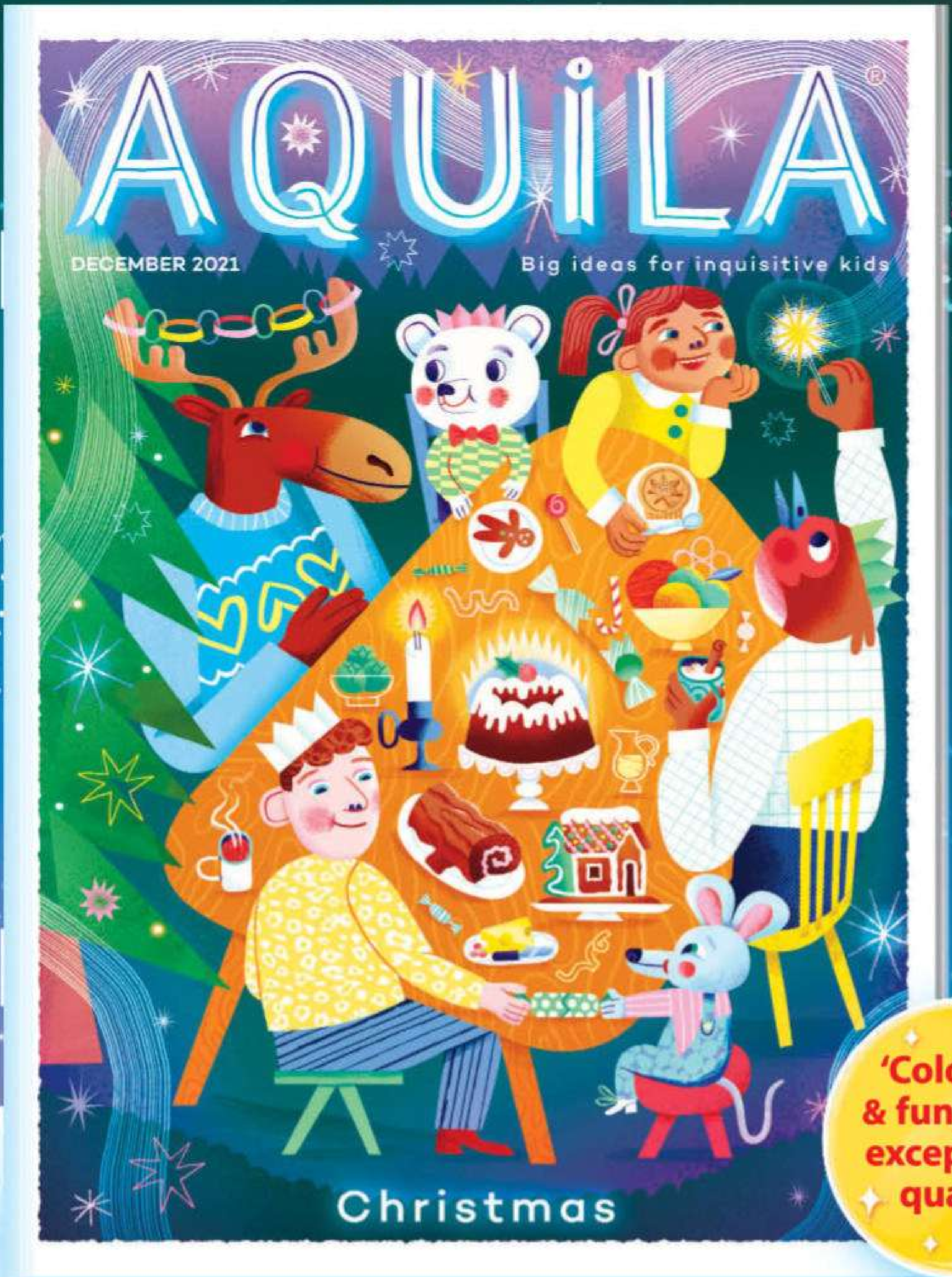

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